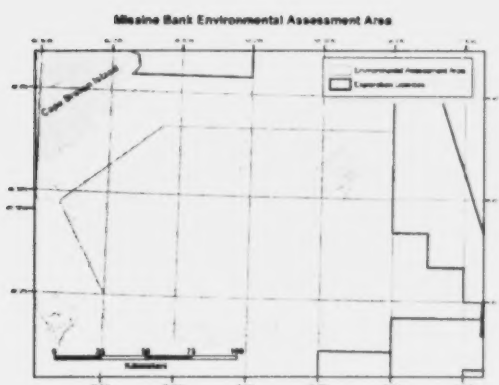


Strategic Environmental
Assessment of the Misaine
Bank Area

Strategic Environmental Assessment of Misaine Bank

DRAFT



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July 4, 2005



Executive Summary

The Canada-Nova Scotia Offshore Petroleum Board (CNSOPB) is undertaking a Strategic Environmental Assessment (SEA) for the Misaine Bank area. This document is a draft assessment report based on the Scoping Document for a Strategic Environmental Assessment for the Misaine Bank, which was finalized following receipt and review of comments from regulatory agencies, stakeholders, and the public. This draft assessment report will be made available for public review and comment for a period of at least 30 days, and will be revised based upon regulatory and public comment. A public review meeting will be held in Sydney, Cape Breton, before the end of the review period.

The SEA is being conducted to provide an overview of the existing environment in the Misaine Bank area, as well as to discuss the potential environmental effects associated with offshore oil and gas exploration activities, identify knowledge and data gaps, highlight issues of concern, and make recommendations for mitigation and planning in the area. This document provides a description of the two primary activities associated with offshore oil and gas exploration: seismic surveys and exploratory drilling. A brief description of the environment is then provided, followed by the assessment methodology and the Valued Ecosystem Components to be used, the types of impacts to be considered, and potential mitigation measures.

Fisheries & Oceans Canada is the lead federal authority for oceans management and provides the national policy context for integrated ocean management. The Department has developed a prototype oceans management plan for the Eastern Scotian Shelf through a public consultation process. The ESSIM (Eastern Scotian Shelf Integrated Management) Draft Management Plan provides general guidance for assessing ocean impacts related to oil and gas exploration, and thus provides important guidance to this SEA.

Analysis of potential impacts suggests that the Misaine SEA area is not more sensitive to the potential effects of oil and gas than other areas of the Scotian Shelf. It is, however, less affected by past human activities, particularly bottom trawling, than many other areas opened to exploration previously. The area also has uncommon topography and may support unusual benthic communities in the numerous deep holes of cold water.

Fisheries for snow crab and northern shrimp within the Misaine SEA area are highly lucrative. The Laurentian Channel, on the eastern edge of the area, is an important migration route for marine mammals. The endangered blue whale, which enters the Gulf of St. Lawrence to feed in the summer, is of particular concern. Also, numerous coastal sites along eastern Cape Breton are sensitive to potential accidental spills of hydrocarbons.

Lack of information on benthic habitat within the area and its relationship to seismic effects, particularly on shrimp, are a concern. Less scientific information has been



gathered within the Misaine SEA area than most other areas where oil and gas exploration has occurred. To reflect this lack of information, and concern by commercial fishermen about the potential importance of the area to the sustainability of their fisheries, it is recommended that Louisbourg Hole be a priority area for the collection of additional baseline information. A review of its ecological importance should be conducted once sufficient new information is available. It is also recommended that, if well site surveys are to be conducted in the area, biological information be collected and made publicly available for incorporation into a baseline database.

New guidelines for seismic surveys have been developed by DFO, in conjunction with other agencies. These guidelines would be adopted for the Misaine SEA area, should it become open to exploration, and will ensure minimal impacts on marine mammals and species of concern listed under SARA.

Other mitigation measures considered in this assessment include:

- prohibition of selected or all exploration activities;
- baseline studies or effects monitoring;
- modified rules for seismic operations dealing with ramping up, response to sightings, or night-time operations;
- use of specially trained observers to deal with specific issues, and
- zero discharge from exploratory drilling operations.

These additional mitigation measures can be applied broadly to exploration activities within the Misaine SEA area. They address the specific sensitivities identified in this SEA, and conform to the guidance provided in ESSIM. They will work to ensure that the residual impacts from oil and gas exploration remain at acceptably low levels. Additional mitigation, particularly with reference to the timing of activities to avoid especially sensitive periods are addressed in project-specific environmental assessments that may follow this SEA should a call for bids be issued.

The Misaine SEA area is less affected by past human activities, particularly bottom trawling, than other areas opened to exploration previously, and likely supports productive and possibly uncommon benthic communities. Still, no reason could be found to exclude exploration for oil and gas from the area.



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1 INTRODUCTION

The Canada-Nova Scotia Offshore Petroleum board (CNSOPB) is undertaking a Strategic Environmental Assessment (SEA) for the Misaine Bank area as outlined in Figure 1-1. A scoping document was prepared and released for public comment to assist the CNSOPB in developing the terms of reference and scope for the assessment. This scoping document was finalized on May 24, 2005, and was made available on the CNSOPB website. Comments were received, and those comments were taken into consideration during the composition of this draft SEA.

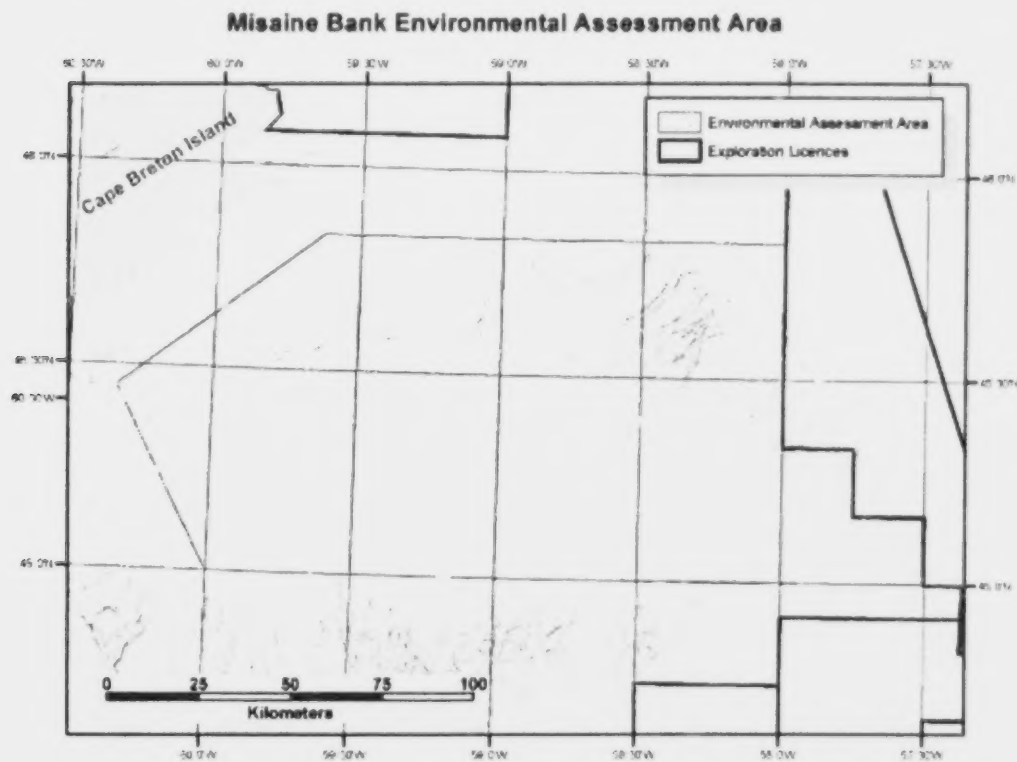


Figure 1-1: Area to be Covered by the Strategic Environmental Assessment

Table 1-1 gives the coordinates for the study area, in both degrees, minutes and seconds, and decimal degrees, referenced to the NAD 27 datum.

Table 1-1: Misaine Bank SEA Study Area Coordinates

Degrees, Minutes, Seconds		Decimal Degrees	
Latitude N	Longitude W	Latitude N	Longitude W
45°50'	59°38'30"	45.83333	59.62500
45°50'	59°0'	45.83333	59.00000
45°50'	58°0'	45.83333	58.00000
45°20'	58°0'	45.33333	58.00000
45°20'	57°45'	45.33333	57.75000
45°10'	57°45'	45.16667	57.75000
45°10'	57°30'	45.16667	57.50000
45°0'	57°30'	45.00000	57.50000
45°0'	59°0'	45.00000	59.00000
45°0'	60°0'	45.00000	60.00000
45°27'	60°20'	45.45000	60.33333
45°50'	59°38'30"	45.83333	59.62500

The Canada - Nova Scotia Offshore Petroleum Board has the responsibility pursuant to the *Canada - Nova Scotia Offshore Petroleum Resources Accord Implementation Act* and the *Canada - Nova Scotia Offshore Petroleum Resources Accord Implementation (Nova Scotia) Act* (the *Accord Acts*) to ensure that offshore oil and gas activities proceed in an environmentally responsible manner. The CNSOPB conducts strategic environmental assessments (SEAs) in portions of the Nova Scotia offshore area that may be offered in a Call for Bids for exploration licences for offshore oil and gas exploration and that have not been assessed by a comprehensive study, a panel review under the *Canadian Environmental Assessment Act* (CEAA), or a public review by a commissioner appointed by the CNSOPB.

This draft assessment report is based on a scoping document, which received commentary from regulatory agencies and stakeholders. This draft assessment report will be made available for public review and comment for a period of at least 30 days, and will be revised based on regulatory and public comment. A public review meeting will be held in Sydney, Cape Breton, before the end of the review period.

SEA is a planning process that examines the environmental effects which may be associated with a plan, program, or policy proposal and allows for the incorporation of environmental considerations at the earliest stages of program planning. SEA typically considers the overall ecological setting rather than a project-specific environmental assessment that focuses on site-specific issues within well-defined boundaries. Additional information regarding SEA may be found on the Canadian Environmental Assessment Agency web site at: <http://www.ceaa-acee.gc.ca>. This SEA addresses its relationship to DFO's Eastern Scotian Shelf Integrated Management (ESSIM) initiative.



This document provides a description of the two primary activities associated with offshore oil and gas exploration: seismic surveys and exploratory drilling. A brief description of the environment is then provided, followed by the assessment methodology to be used, the types of effects to be considered, and potential mitigation measures.

1.1 Objectives

The Misaine Bank SEA will consider petroleum-related activities that may occur offshore if one or more exploration licences are issued. An exploration licence confers:

1. the right to explore for, and the exclusive right to drill and test for, petroleum;
2. the exclusive right to develop those portions of the offshore area in order to produce petroleum, and
3. the exclusive right, subject to compliance with the other provisions of the *Accord Act* to apply for a production licence.

Associated activities may include drilling of either exploration or delineation wells, in addition to seismic and other geophysical surveys. All of these activities require the specific approval of the CNSOPB and each requires a project-specific assessment of its associated environmental effects. The SEA does not replace the need for site-specific EAs, but provides an overview of the existing environment in the Study Area, and identifies any major environmental effects associated with offshore oil and gas activities that may differ from past experience in Nova Scotia offshore waters. It will identify knowledge and data gaps, highlight issues of concern, and make recommendations for mitigation and planning. Information from the SEA will assist the CNSOPB in determining whether exploration rights should be offered in whole or in part for the area, and may also identify general restrictive or mitigative measures that should be considered for application to exploration activities within new exploration licences.

The Misaine Bank SEA will identify features in the study area that might pose different environmental problems from those common to the wider Scotian Shelf, or which may need to be addressed differently by the oil and gas industry or its regulators. The SEA may identify general restrictive or mitigative measures and monitoring requirements that should be considered for application to exploration activities.

1.2 Rationale for this SEA

The 1986 *Accord Acts*, establishing the Canada-Nova Scotia Offshore Petroleum Board (CNSOPB), are mirror legislation under authority of the Ministers of Natural Resources Canada and the Nova Scotia Department of Energy. The *Acts* give the Board the responsibility to regulate oil and gas activity in the Nova Scotia offshore, including:

- health and safety for offshore workers;



- protection of the environment during offshore petroleum activities;
- management and conservation of offshore petroleum resources;
- compliance with the provisions of the Accord Acts that deal with Canada-Nova Scotia employment and industrial benefits;
- issuance of licences for offshore exploration and development, and
- resource evaluation, data collection, curation and distribution.

This SEA is focused on environmental protection. To ensure that opportunities for economic and employment benefits are provided to Nova Scotians and Canadians, the Board requires a Canada-Nova Scotia Benefits Plan be submitted before exploration or production activity proceeds. Together, the Natural Resources Canada and the Nova Scotia Department of Energy support the use of a SEA to support the Government of Canada Cabinet Directives regarding sustainability and the Province's Energy Strategy. The intent is to ensure that environmental considerations are taken into account when issuing exploration rights.

Current geoscience knowledge and comparison to similar geological structures around the world suggest oil and gas reserves may be found in the Misaine SEA area. The Orpheus Graben, covering about 20,000 km² (50 km by 400 km), is the dominant feature of this area (Figure 1-2). The maximum sediment thickness in the area is not known for certain but may exceed 12 kilometers at its eastern end.

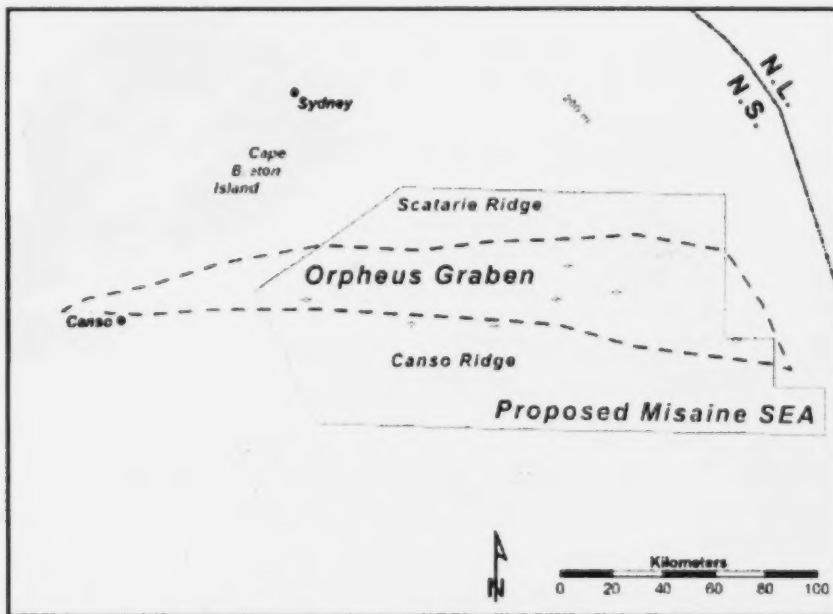


Figure 1-2: Relationship of the Orpheus Graben to the Proposed Misaine SEA Area

Seven exploration wells were drilled within (4) and along the edge of (3) the basin during the early 1970s (well symbols are shown at these locations in Figure 1-2). They drilled faulted, basement- and salt-related structures utilizing then-current knowledge and understanding, with exploration targets based on seismic data of very limited quality and quantity. No hydrocarbon shows were encountered in the original wells.

2 EXPLORATION ACTIVITIES

2.1 Seismic Surveys

Seismic surveys use underwater sound generated by sudden releases of compressed air to map geological structures under the seabed. Pressure waves from the airguns reflect at the boundaries of different rock types, and these reflected waves are picked up at a series of receivers towed behind the survey vessel. Computer-based data processing systems convert the reflected sound into seismic displays that can be used to map possible hydrocarbon accumulations.

An offshore survey vessel is typically 80 to 95 m long, with a crew of approximately 40 personnel (Davis et al. 1998). An array of airguns towed 4 to 10 m below the water surface behind a survey vessel provides the high intensity energy source. The vessel runs a series of lines at a speed of approximately 3.5 to 5.5 knots (6.5 to 10 km/h).

The sound source is typically discharged approximately every 25 m (10 to 12 seconds) and directs the largest amount of sound downward toward the sea floor. Reflected sound energy from below the sea bottom is recorded by one or more hydrophone arrays (streamers) towed behind the survey vessel. These streamers are typically 3 to 6 km long.

Seismic surveys can be two-dimensional (2D) or three-dimensional (3D). 2D seismic surveys typically cover relatively large geographical areas and generally spend less time within a small specific area than 3D surveys. Survey lines tend to be more than 1 km apart, and often run in different directions. 2D surveys use a single source array and a single streamer (receiver).

3D seismic surveys provide a much greater resolution of underground structures. 3D surveys are substantially more expensive and are not always done prior to exploratory drilling. 3D surveys tend to concentrate activity over a relatively small geographical area for extended periods (often weeks at a time), with survey lines usually spaced several hundred metres apart (Davis et al. 1998). 3D surveys typically use multiple source arrays and 6 to 8 streamers (receivers).

An exploration licence confers the exclusive right to undertake drilling activity, but is not required to conduct seismic surveys. Therefore, seismic survey areas often extend beyond exploration licence boundaries.



2.1.1 Seismic Sound Propagation

Seismic shots, or bursts of energy from airguns, are of short duration, at most a few tens of milliseconds (ms). Peak energy levels in a shot is high, but the short duration of the shot means that the total energy transmitted into the water column is low compared to a continuous release. Most of the sound produced by an airgun array is in the range of 10 to 300 Hertz (Turnpenny and Nedwell 1994). Seismic airguns are designed to produce primarily low frequencies, but a broad spectrum of signal is generated, particularly to the side. The shape of the pulse also influences its potential environmental effect.

The total airgun volume in the array and the operating pressure of the guns determine the amplitude of the acoustic signal. Marine airgun arrays normally have a total volume of between 2,000 and 4,000 cubic inches and operate at approximately 2,000 pounds per square inch (psi). The peak sound pressure level generated by such arrays would be between 240 and 260 dB re 1 μ Pa @ 1 m.

The sound amplitude from a seismic array diminishes (attenuates) with increasing distance from the source. Attenuation is a function of the logarithm of the distance from the source, meaning it is rapid close to the source, but more gradual at longer distances. As the distance increases, the amplitude of the sound diminishes and the frequency spectrum broadens.

A range of activity and site-specific factors may also influence sound propagation in the marine environment. For example, sound levels and frequencies can vary, and oceanographic characteristics (e.g., sea bottom roughness, water depth, temperature, and salinity) can also influence attenuation as it propagates through the water (Davis et al. 1998). Sound propagation in shallow water, for example, is more strongly attenuated, especially at low frequencies, compared to deeper waters. Stratification of the water column can also provide channels that promote the transmission of sound over long distances.

Davis et al. (1998) provides a more thorough review of sound propagation. Background noise levels are also important in determining the impact of the sound from seismic surveys, especially at distances of greater than one kilometre. The hearing sensitivity of organisms will also play a role in the magnitude of impact on biota.

2.1.2 Other Influences on the Environment

Vessel traffic, including survey and possible guard vessels, can also have effects on the environment. Other operational concerns include vessel discharges, such as deck drainage, vessel exhaust, and the presence of vessels and lights at night.

2.1.3 Potential Accidental Effects

Unlike exploratory drilling, the risk of releasing oil or gas to the environment during seismic surveys is the same as for any typical ship. As is the case with any marine vessel,



accidents may occur, ranging from small spills of fuel, to releases from seismic streamers, to possible collisions with marine life, fishing gear, and/or other vessels.

2.2 Exploratory Drilling

Hydrocarbons are found in porous rock structures, which may contain oil and gas accumulations that are large enough to be commercially developed. Exploratory drilling is the only way to confirm the presence and nature of hydrocarbons (oil, gas, condensate, % water, or a combination of these) that seismic survey results indicated may be present. Selection of specific sites for exploratory drilling can only be determined following analysis of seismic data.

If hydrocarbons are found during exploratory drilling, testing may be required to further define the potential for development. The results of these tests may give some indication about whether hydrocarbons may be present in quantities that are economical to develop.

Appraisal and/or delineation wells may be required if the presence of commercial quantities of hydrocarbons is indicated. These wells are drilled at a new location over the same prospect (or reservoir). They are required to determine the area and volume of the discovered hydrocarbons. The size and structural complexity of the accumulation will decide the number of appraisal/delineation wells required.

Drill rigs may be anchored directly on the bottom or floating. Floating rigs, including drill ships, can be anchored to the bottom or dynamically positioned.

Jack-up rigs are generally used in waters less than 80 m deep. They are towed to the drill site, where their movable legs are jacked down onto the sea bottom, elevating the rig platform until it is about 20 m above the water surface. The type of bottom support used for the legs depends on the softness of the bottom. If the bottom is unstable, large steel mats can be used to support the rig legs; where the bottom is solid, steel cylinders ("spud cans") are attached to each leg.

Semi-submersible rigs might also be used, if the water at the well sites is deep enough. These rigs are towed to the drill site where the bottom part of the rig is flooded, and the rig moored to the bottom with a series of 6 to 10 anchors. Most semi-submersibles rely on anchors, but a few use a dynamic positional system with multi-directional thrusters.

Drill ships are unlikely to be used in the Misaine Bank area because the moderate depths favour less expensive rigs.

Drill rigs are usually self contained and include a derrick and drilling equipment, a helicopter pad, fire and rescue equipment and crew quarters. Rigs usually have one to three support vessels in attendance. They need to be supplied with drilling equipment, fuel, food, and many other materials and supplies to maintain a crew, vessel, and drilling



operations. In addition, there are regular crew changes and visitors that need to be carried to and from the platform.

2.2.1 Support Vessels and Aircraft

Materials are transported to drill rigs by supply vessels approximately three times per week. A series of dedicated 24-hour stand-by vessels also attend the rig throughout the drilling operation. Crews and some supplies are also routinely transferred to the offshore by helicopter.

2.2.2 Discharges

Drilling muds may be water-based (WBM), oil-based (OBMs), or synthetic (SBMs). WBM are typically used, but OBMs or SBMs may be used with permission from the CNSOPB following review of specific environmental assessment of the impacts. The release of OBMs is prohibited, and the only release of SBMs to the local marine environment permitted is through that remaining on cuttings discharged. The main component of any WBM is seawater, with bentonite (clay) and barite as the primary additives. WBM are proprietary mixtures, and each contains its own blend of chemicals. The typical volume of water-based mud constituents discharged per well, for a single well drilled 5,000 m deep, is shown in Table 2-1 (from Thomson et al. 2000).

Table 2-1: Typical Volume of Water-Based Mud Constituent Discharged Per Well

CONSTITUENT	TONNES
TOTAL CUTTINGS GENERATED	1235.0
MI GEL	107.6
MI BAR	219.2
CAUSTIC SODA	2.2
SODA ASH	0.6
LIME	0.1
SPERSENE CF	0.5
DRILLING DETERGENT	1.1
POLY PAC	6.7
XCD KELZAN	2.4
POLY PLUS	5.4
POTASSIUM CHLORIDE	107.8
DEFOAM X	0.4
CALCIUM CARBONATE	24.6

Offshore drilling platforms also routinely produce a variety of other wastes including:



- grey and black water (showers, dishwashing, deck drains);
- ballast water/preload water;
- bilge water;
- deck drainage;
- discharges from machinery spaces;
- garbage, and
- cooling water.

The amount of these discharges can vary with variables such as weather conditions. Thomson et al. (2000) estimated discharges of grey and black water to be 40 m³/day and 19 m³/day respectively, for a floating drilling platform with 100 people. Treatment of these wastes will follow the NEB/CNSOPB/C-NLOPB Offshore Waste Treatment Guidelines in effect at the time.

2.2.3 Duration and Timing

The drilling of a single exploration well typically requires between 40 and 100 days, depending on the complexity of the well, environmental conditions, and well depth. Testing, if hydrocarbons are found, may encompass a broad array of activities and usually requires from 10 to 40 days.

Because of unfavorable ice and weather conditions, exploratory drilling would unlikely be carried out between the months of January and April/May.

2.2.4 Hazards Survey

Prior to setting up jack-up rigs, a hazard survey is conducted at each well site to make sure conditions will support the rig legs (or spuds) and no potential shallow gas accumulations exist near the surface that the well bore would penetrate. Site surveys acquire high-resolution seismic data, sub-bottom profiles, sidescan sonar images and bathymetry concurrently. Grab samples and bottom camera photographs are taken where appropriate. The actual geometry of the surveys may be adjusted during acquisition to account for water depth. The choice of sub-bottom profiler (shallow or deep tow) is dependent on water depth. Airgun arrays used in hazards surveys are substantially less powerful than those used in seismic surveys.

2.3 Exploration Alternatives

Seismic surveying using air guns as a sound source is the current industry standard for collection of geophysical information thousands of metres below the seabed. Seismic surveys are conducted to identify potential underground structures that may hold hydrocarbon reserves. Exploratory drilling is conducted on promising structures to verify the presence of hydrocarbons and to provide information on flow rates and quality.



Alternatives to a project are defined as functionally different ways of achieving the same end (CEA Agency 1997). A seismic survey is a cost-effective means to determine if underground structures have sufficient potential for oil and gas deposits to explore further.

Alternative means for the project can be defined as methods of similar technical character or methods that are functionally the same (CEA Agency 1997). Alternative means of exploration surveying include use of different sound sources, such as explosives or vibrating devices. In relation to exploratory drilling, different types of drilling muds may be used.

Conducting marine seismic surveys is expensive, but much less expensive than exploratory drilling. Information obtained by seismic surveys substantially reduces the cost of exploration. If seismic surveys were not generally permitted in marine environments, exploratory drilling and/or production would not occur.

3 PHYSICAL ENVIRONMENT

The surface of Misaine Bank is extensively marked by channels and canyons that resulted from glacial and ice melting processes. This is expected to have an impact on the circulation in the area and at the same time make the modeling of waste dispersion near the bottom a complex issue, due to the intricate character of the interactions between the flow and the irregular bottom floor. The relative simplicity of the current systems around Sable Island (clockwise current circulation with dominant easterly flow on the north and westerly to northwesterly flow on the south) will not be observed here.

3.1 Surficial Geology

The Misaine Bank area has been substantially affected by glacial activity, from multiple glacial events. The topography of the bank can be attributed to sub-aerial erosion of the bedrock during low-stand events (MacLean and King 1971). The topography of the surficial sediments closely follows the contours of the underlying bedrock.

Figure 3-1 shows that the surficial sediments of the Misaine SEA area comprise primarily Sable Island sand and gravel, and Sambro sand and Laurentian sand (MacLean and King 1971). The Sable Island sand and gravel unit consists of fine- to coarse-grained, well-sorted sand that laterally grades into gravel. This formation overlies the Scotian Shelf drift and glacial till. The Sambro sand unit is a coarser-grained lateral extension of the Emerald silt unit, and underlies the Sable Island sand and gravel unit. The Laurentian sand is an informal name for the extension of this unit into the Laurentian Channel. This unit is composed of fine- to coarse-grained sand, with some silt, clay and gravel. This unit is most likely derived from the underlying glacial till unit.



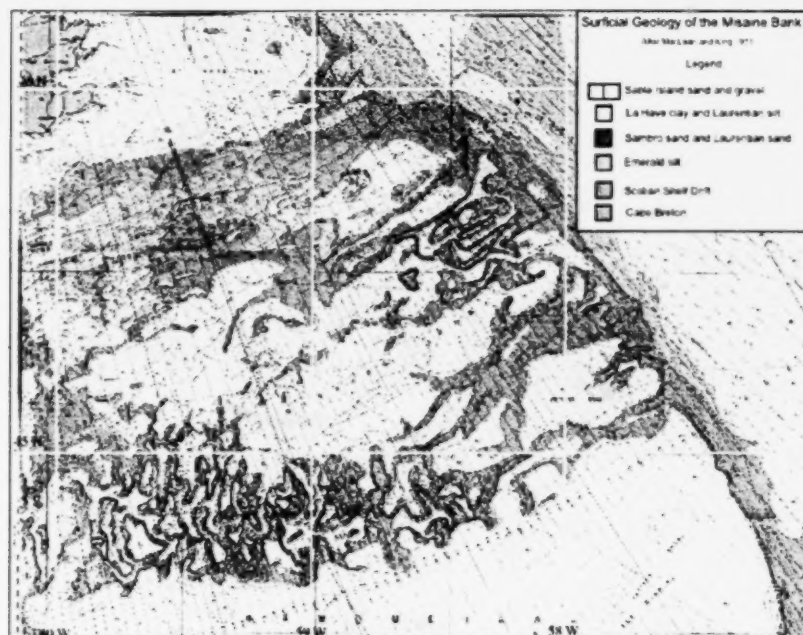


Figure 3-1: Surficial Geology of the Misaine SEA Area

Basins on the Misaine Bank are filled with clay and silt from the La Have clay and Laurentian silt unit, and the Emerald silt unit (MacLean and King 1971). The La Have clay is dark grey clayey silt that grades to sandy silt. The Laurentian silt unit is the equivalent to this unit as it occurs in the Laurentian Channel. The Emerald silt unit consists of poorly sorted clayey and sandy silt, often with some gravel. This unit underlies the La Have clay in depressions in the Misaine Bank area.

Underlying these units in most areas of the Misaine Bank is the Scotian Shelf drift and Laurentian drift unit. This unit is formed from glacial till, composed of sand with silt and clay and some gravel. The sediment is poorly sorted and consists of quartzite, granite and sandstone fragments.

Seismic studies show that these sediments are derived from the onshore bedrock, so they have a composition similar to these granites and sedimentary rocks. The sediments and sedimentary rocks overlying the bedrock on the Misaine Bank can be as thick as 50 metres (Josenhans et al. 2004).

3.2 Oceanography of the Scotian Shelf

The Misaine Bank lies north of the western sector of Banquereau Bank. It is located southeast of Cape Breton Island, and it is bordered by the Laurentian Channel from the northeast and the Sable Island Bank from the southwest. It is approximately 130



kilometres long by 65 kilometres wide with depths varying between 70 and 100 metres over a rocky and broken bottom.

The geographic location of Misaine Bank and its topographic characteristics confer the bank distinctive hydrographic and hydrodynamic conditions that differ from those of the surrounding areas.

A brief description of the oceanographic conditions of water bodies surrounding Misaine Bank is offered below.

3.2.1 General Conditions on the Scotian Shelf

Circulation patterns on the Shelf primarily result from the convergence of three major ocean currents.

- the Nova Scotia Current flows southwesterly out of the Gulf of St. Lawrence through the Cabot Strait. A portion of this year round current then turns westward near Cape Breton Island and moves along the Nova Scotia coast. East of Cape Breton Island, the rest of the outflow continues to move seaward over the shelf and on the western side of the Laurentian Channel.
- the cool Labrador Current flows southwesterly from the Labrador Sea and shelf until it joins with the offshore branch of the Nova Scotia Current. It then moves along the edge of the Scotian Shelf.
- the warm Gulf Stream Current flows south of the Scotian Shelf in a northeasterly direction. Clockwise flows around the offshore banks and counterclockwise flows around the deep basins characterize circulation patterns in the area.

Current modeling efforts on the Scotian Shelf have revealed the presence of partial gyres that encourage retention of particles and marine organisms such as plankton. (Cong et al. 1996, Hannah et al. 2001). The retention areas produced by these gyres are thought to be of biological importance for events such as spawning.

Phenomena known as internal waves occur at the shelf edge where the steep topography interacts with the diurnal tides. These waves produce a mixing of water layers across the thermocline and draw nutrients and phytoplankton down to deeper layers. This occurrence is particularly prevalent on the Southwest Peak of Banquereau Bank.

Surficial geology consists primarily of sand and gravel deposits of various sizes in water depths of less than 100 metres, while sand with silt and clay mixtures are found in the deeper areas. A long sand-ridge system stretches from Sable Island Bank to Banquereau Bank including Sable Island, and is perhaps the remnants of a barrier island system, now long submerged (Amos and Knoll 1987).



3.2.2 Laurentian Channel

The Laurentian Channel is a deep submarine valley of glacial origin ranging in depth from 180-550 metres that originates on the Atlantic continental shelf off Nova Scotia and ends near the mouth of the Saguenay Fjord. It serves as one of the two pathways for communication between the Gulf of St. Lawrence and the Atlantic Ocean and the only one below 200 m. It is generally accepted that part of the offshore branch of the Labrador Current flows westward around the tail of the Grand Banks, along the continental slope to the Laurentian Channel and the Gulf of St. Lawrence (Colbourne 2002). Some studies report that about 50% of the flow around the Tail of the Grand Bank reaches the Laurentian Channel area (Loder et al. 1997).

The Laurentian Channel has been reported to have a vertically structured circulation system (Koutitonsky and Bugden 1991). This leads to saltier, relatively warmer water moving from the Atlantic Ocean into the Gulf of St. Lawrence occupying the deeper layers of the channel, while fresh and colder water resulting from river runoff and ice melting processes lies near the surface and moves generally seaward. According to this scheme, a warm layer forms near the surface, leaving a cool intermediate layer below.

However, Han et al. (1999), using a three-dimensional diagnostic model (forced by baroclinic pressure gradients, seasonal wind stresses and additional barotropic inflows across the Strait of Belle Isle and southern Newfoundland shelf upstream boundaries) to compute circulation fields from high-density seasonal temperature and salinity fields, obtained a rather horizontally structured flow, with an inflow of water from the Atlantic ocean close to the Newfoundland shelf that may reach speed values over 20 cm/sec, while the west half of the strait is generally occupied by outward flows with higher speeds (40 cm/sec) near the surface.

The analysis of current meter data (BIO 2003) covering a one-year period between 1996 and 1997 at four depths ranging from 50 to 680 m, shows that at 50 m, mean monthly current speeds in the area ranged from 0.073 m/s (April) to 0.334 m/s (June). At 150 m, average monthly current speeds in this area ranged from 0.038 m/s (May) to 0.192 m/s (November), while at 680 m, mean currents ranged from 0.003 m/s (June) to 0.041 (May). Maximum current speeds at 50 m at that location ranged from 0.307 m/s (May) to 0.822 m/s (December).

The tidal influence in this area is also important, and locally reverses the direction of the flows (Dinsmore 1972).

3.2.3 Sable Island Bank

Sable Island Bank, located to the southwest of the study area, is one of a series of large, shallow banks that make up the outer Scotian Shelf. The bank is influenced by cool, coastal water and warm, saltier slope water, as well as tides and offshore currents. Tidal currents produce a general clockwise circulation pattern around the edge of the bank.



Sand and gravel make up the surficial geology of the bank, with sand predominating (Amos and Nadeau 1988).

3.2.4 Banquereau Bank

Similar to Sable Island Bank, Banquereau Bank is a large shallow bank situated on the outer Scotian Shelf. It also has a clockwise water circulation pattern around the outer edge of the bank. The surficial geology is comprised of sand and gravel with smaller amounts of gravel present (Amos and Nadeau 1988). Organic matter and very fine suspended sediments are thought to move off the bank into canyons, driven by bottom currents. The Southwest Peak of Banquereau Bank has a particularly high level of tidal mixing and is highly productive (Rutherford and Breeze 2002). The northern edges of the bank have many steep sided hanging valleys formed by glacier meltwater running over their edges.

3.2.5 Scotian Shelf Break

Circulation along the Scotian Shelf break is dominated by a southwesterly flow that originates from Greenland and the Labrador Sea (Pickart and Smethie 1993). On occasion, the area is also affected by the Gulf Stream and its associated rings and eddies. The Gulf Stream flows eastward and is located generally south of 40° N, but shifts seasonally. Warm-core eddies are spun off from the Gulf Stream into the cooler Scotian Shelf water, and conversely cold-core eddies form south of the Gulf Stream. A preliminary analysis of the nearby mooring deployed by Bedford Institute of Oceanography (BIO) between June 2000 through November 2000 reveals that observed currents at approximately the 65 m depth averaged less than 20 cm/s. Currents were less than 46 cm/s 99 percent of the time, and peaked at 59 cm/s. Surface currents would be somewhat higher.

3.2.6 Scotian Slope

The Scotian Slope encompasses a large offshore area extending from the outer boundary of the Scotian Shelf (at a depth of approximately 200 metres) to the political and resource management boundaries at depths of between 4000 and 5000 metres. Scientific knowledge for most areas of the Scotian Slope is lacking in many respects. With the exception of the Gully area, no comprehensive studies have been conducted to date. Due to a lack of systematic surveys of seabirds, sea turtles and marine mammals, there is a knowledge gap with respect to information on abundance and distribution. As well, information regarding primary productivity, zooplankton, and benthic invertebrates is scarce.

The water mass found over most of the slope, called warm slope water, occurs when water from the Gulf Stream mixes with the Labrador Current. Slope water can sometimes be transported into the Gully, particularly during summer and fall. The Gully is known to have complex circulation patterns as well as a high degree of vertical mixing. Circulation



patterns in the Gully suggest it may play an important role in two ways: (1) in the localized retention of materials and (2) in the larger scale transport of materials onto and off the shelf (DFO 1998a).

3.3 Oceanography of the Misaine Bank Area

The surface of Misaine Bank is extensively marked by channels and canyons, which resulted from glacial ice-melting processes. On occasion, particular relief features (e.g., channels and canyons) will confine the flow within certain paths depending on the location. However the relative simplicity of the current systems around Sable Island (clockwise current circulation with dominant easterly flow on the north and westerly to northwesterly flow on the south) is not present here.

3.3.1 Ocean Currents

Bottom irregularities present physical barriers to the circulation in the area and at the same time makes the modeling of waste dispersion near the bottom a complex issue, due to the intricate character of the interactions between the flow and the irregular bottom floor. Tidal mixing, a key factor in the estimation of settling rates for drilling wastes, needs to be assessed alongside other characteristics of the predominant flows. Some efforts in this direction have been done for other sectors of the Scotian Shelf (Loder et al. 1992), but particular studies for Misaine Bank will be needed.

There is a substantial lack of information on measured current data in Misaine Bank. For that reason, in order to assess the most probable characteristics of the circulation, Webdrogue, a graphical user interface to a drift trajectory program that calculates drift predictions for any point in the model domain (B.I.O, http://www.mar.dfo-mpo.gc.ca/science/ocean/coastal_hydrodynamics/WebDrogue/webdrogue.html) was used.

The drift trajectories were computed using tides, the seasonal mean circulation, and a surface-wind drift. The technique for computing the wind-driven circulation and for combining all the circulation components is described in Hanna et al. (2000).

Five more or less evenly distributed points were arbitrarily selected on Misaine Bank. For these points, drift trajectories were computed at three depths and for different seasons for a period of thirty days. The results are shown in Figures 3-2 to 3-4. In these figures the starting point of the drift trajectories is marked with a coloured dot. According to the result of the simulations, currents in the eastern sector of Misaine Bank tend to flow to the east and southeast until they reach the shelf break, and then go around the edge of the Scotian Shelf, eventually turning to the southwest. This general pattern is observed for almost all the seasons and depths included in the analysis. The consistent appearance of flows bordering the eastern Scotian Shelf break in a clockwise direction may be related to



the presence in the area of the seaward flows reported for the western Laurentian Channel by Han et al. (1999).

The picture in the western sector of Misaine Bank is less certain. The simulations there show currents with southwest directions at 0 and 25 m, while at 100 m currents go to the northeast or form cyclonic or anticyclonic gyres around the starting point.

It is important to note that due to the irregular configuration of the bottom topography in the area, these simulations' results should not be considered definitive, since they are not a good substitute of direct marine current measurements.

Tidal currents in the area may reach almost 20 cm/sec and the major axis of the tidal variability is oriented at a northeast/southwest direction.

According to the data collected at the Marine Environmental Data Service's Misaine Bank hydrographic station (<http://www.meds-sdmm.dfo-mpo.gc.ca>), temperature at the surface ranges from slightly below 0°C in February to around 16°C in August (Figures 3-5 and 3-6), which is one of the highest temperature variability ranges anywhere in the Atlantic Ocean (DFO 2003).

This wide temperature variability dramatically diminishes with depth, and near the bottom it is reduced to a range from 1°C in May to 2.5°C in the months of December and January.

Figure 3-7 shows the annual variability of the vertical profiles of temperature and salinity for Misaine Bank according to the BIO's Climatic Hydrographic Database (http://www.mar.dfo-mpo.gc.ca/science/ocean/database/data_query.html). During the months from June to October, a relatively strong thermocline develops in the upper 50 m of the water column, while from January to April, there is a consistent temperature growth with depth.

The vertical distribution of temperature and salinity in Misaine Bank differs from the picture we encounter on the adjacent Scotian Slope. The communication between Misaine Bank and the Scotian Slope below 50 m is hampered by the threshold that separates Banquereau Bank from the adjacent slope to the south. This is evident in the vertical distributions of temperature and salinity shown in Figure 3-7. Location of the Louisbourg oceanographic monitoring line is shown in Figure 3-8. Thus, the layer of warm water (above 10°C) present at around 100 – 150 m on the Scotian Slope is absent on Misaine Bank.



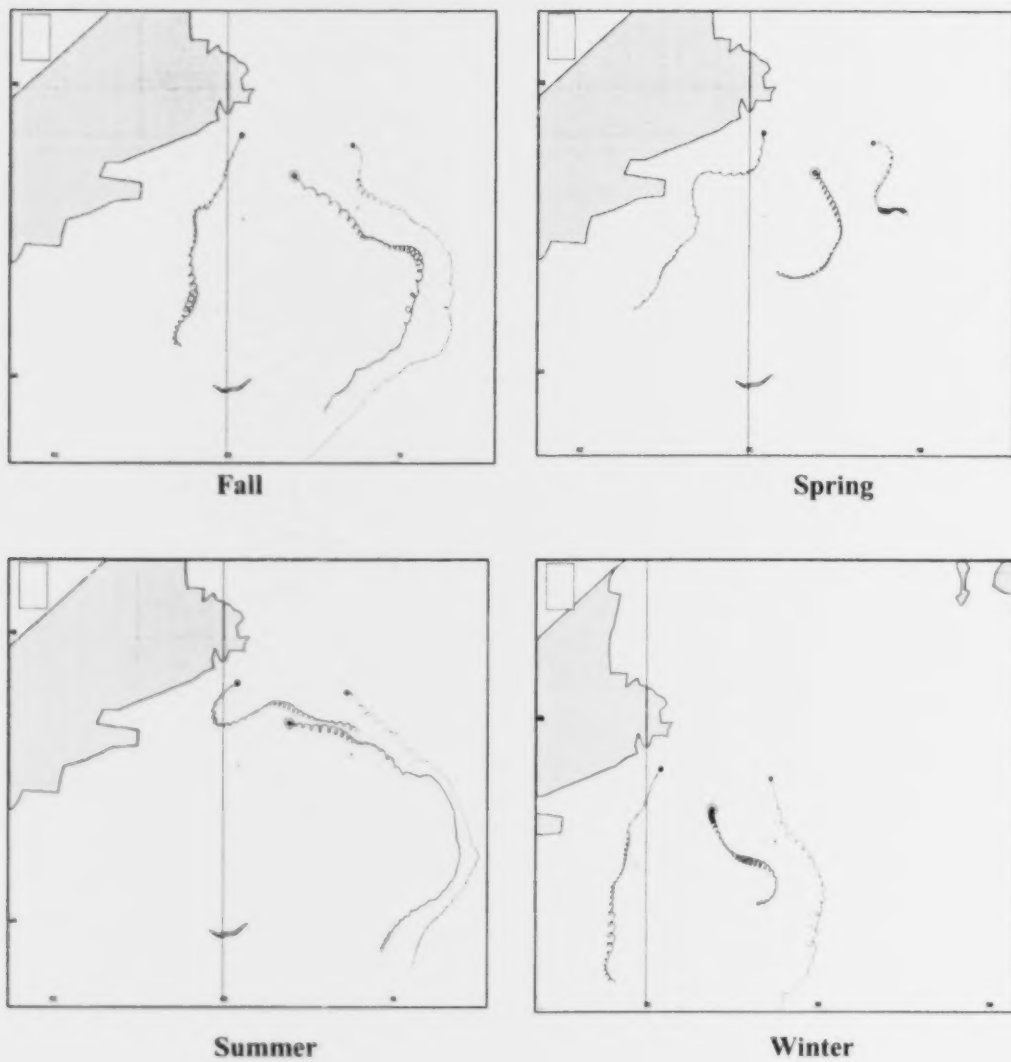


Figure 3-2: Modeled Drift Trajectories at the Surface



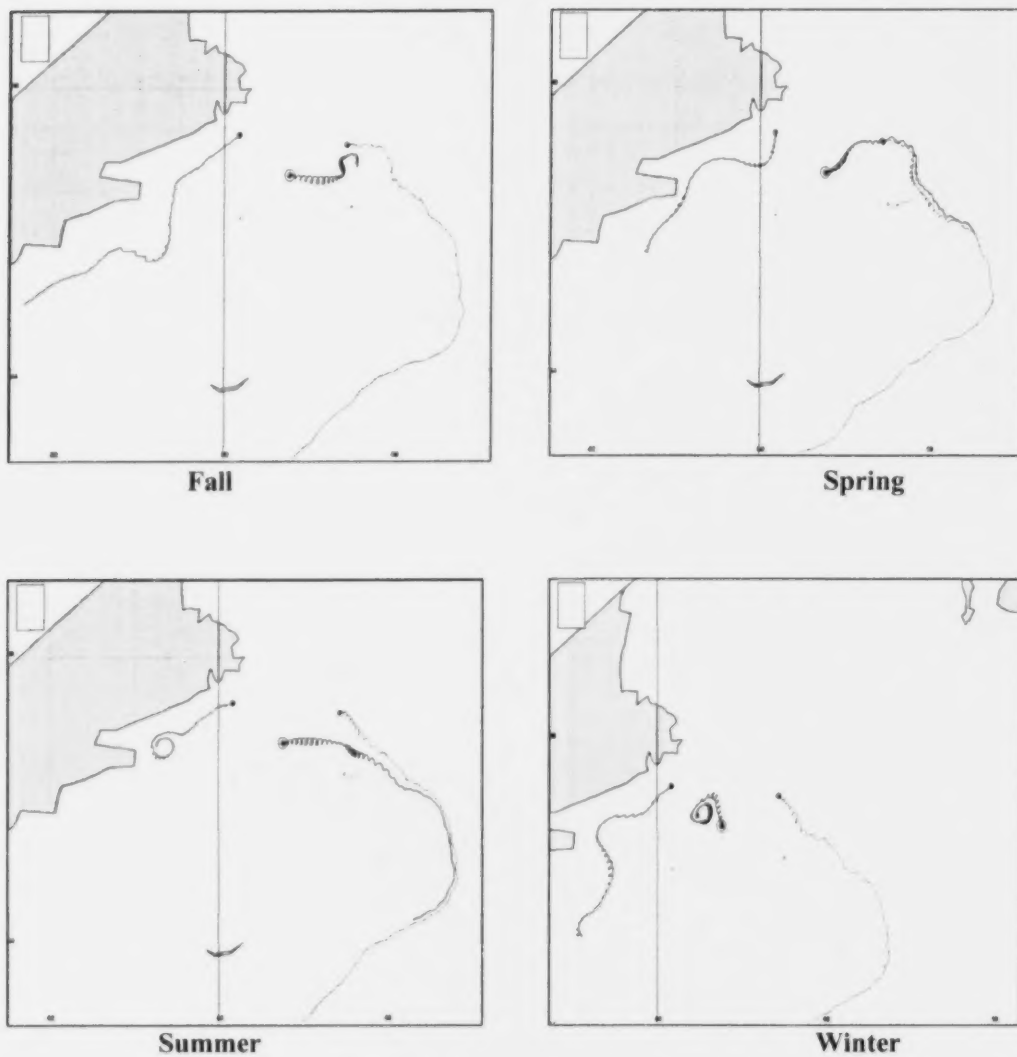


Figure 3-3: Modeled Drift Trajectories at 25 m

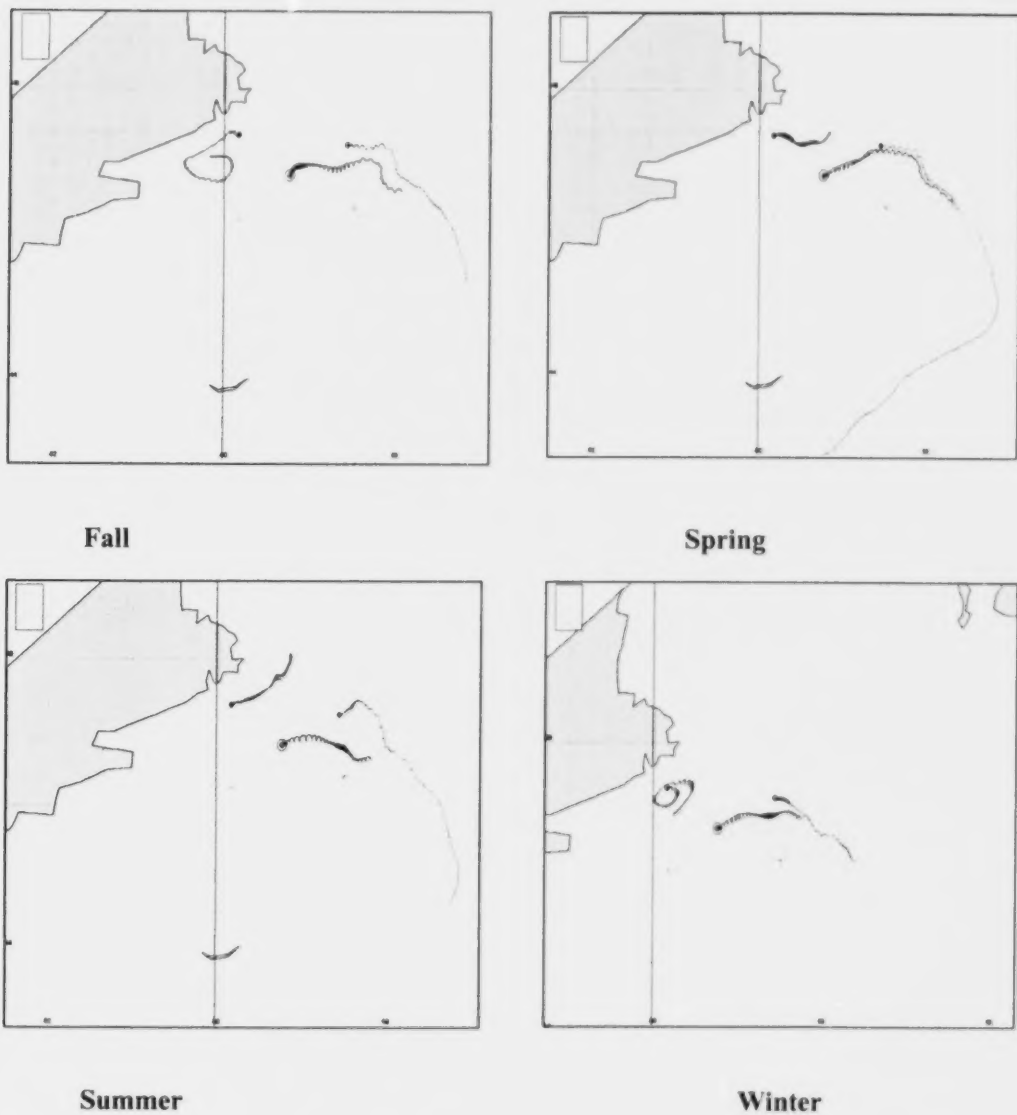


Figure 3-4: Modeled Drift Trajectories at 100 m

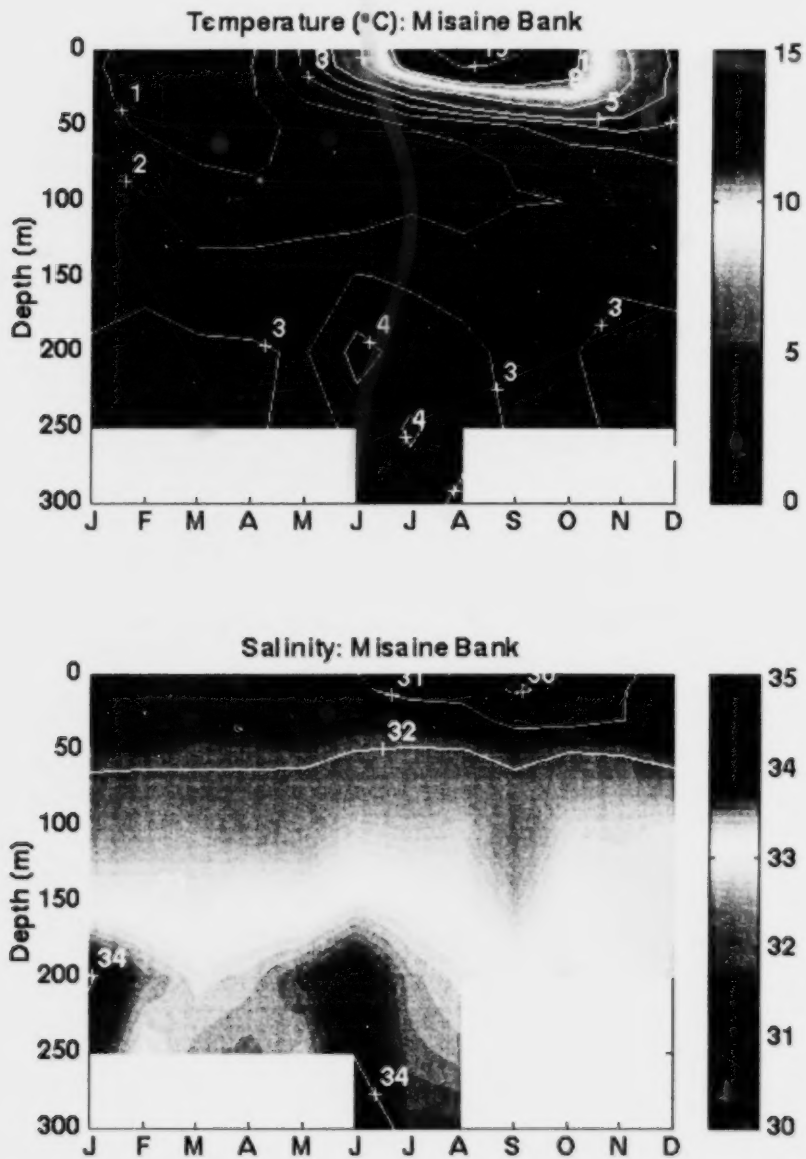


Figure 3-5: Annual Temperature and Salinity Variability for Misaine Bank

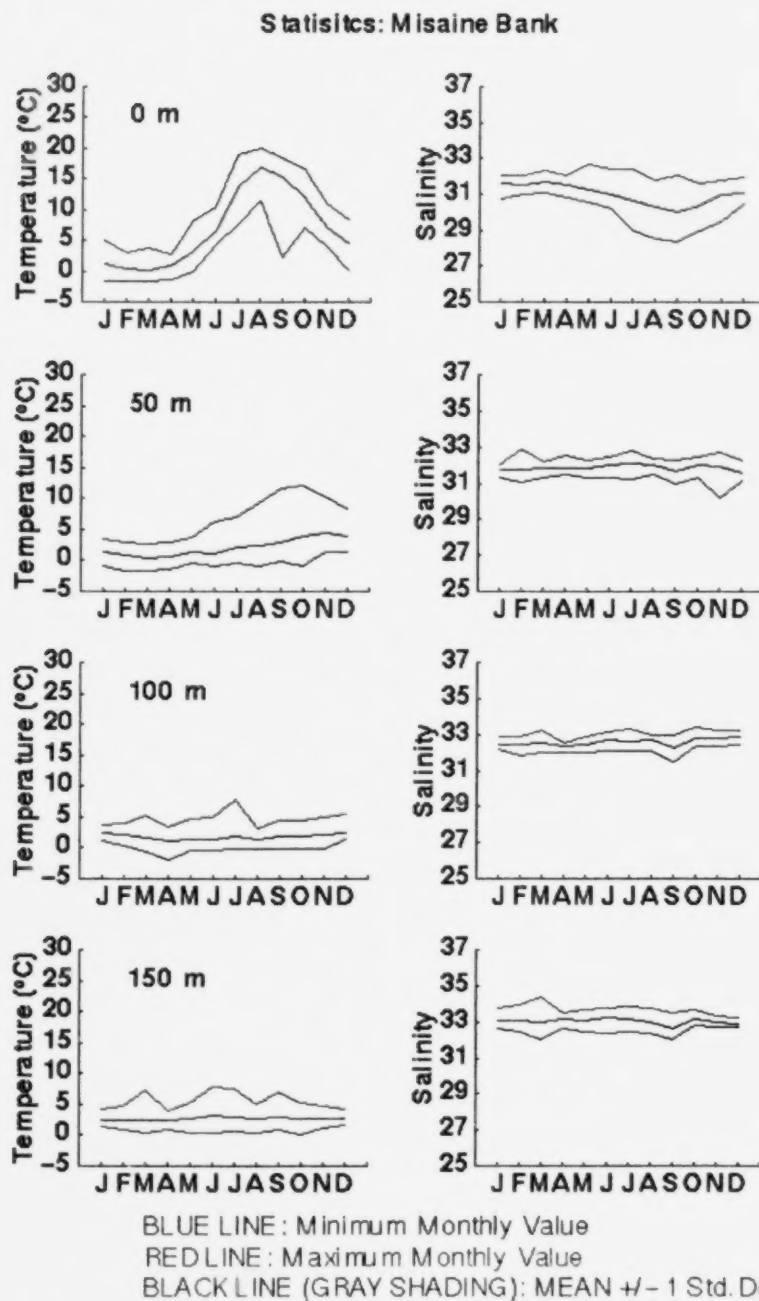


Figure 3-6: Seasonal Cycle of Temperature and Salinity for Misaine Bank

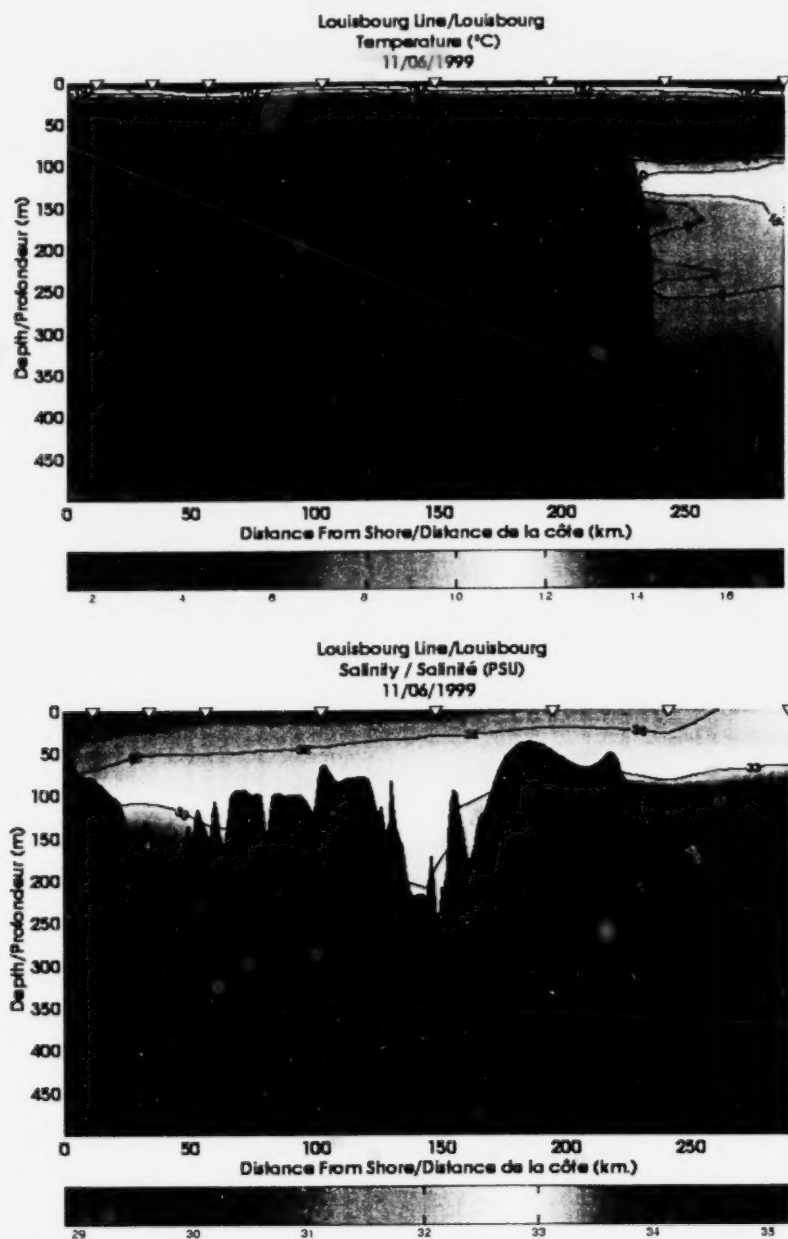


Figure 3-7: Vertical Section of Temperature and Salinity Distributions on the Louisbourg Line during June 1999 (Misaine Bank lies within the first right hand 100 km of the section).

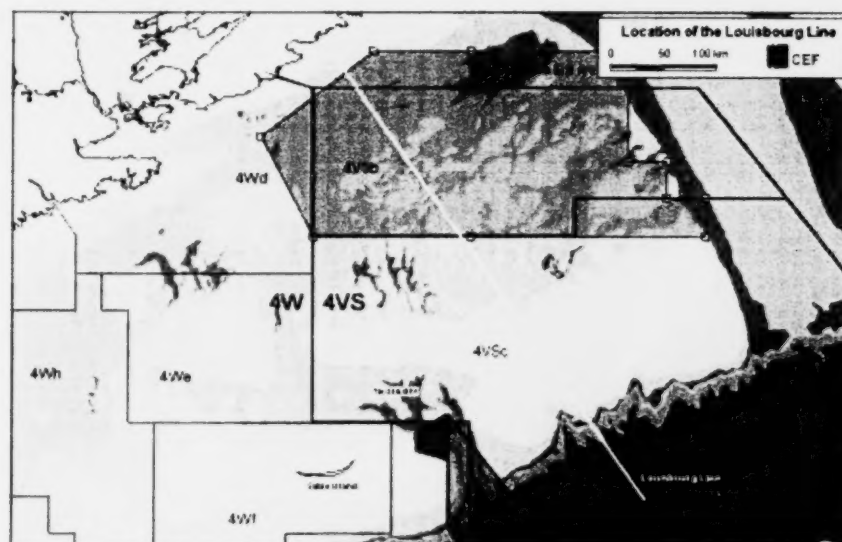


Figure 3-8: Location of the Louisbourg Oceanographic Monitoring Line

3.4 Winds

Wind statistics were generated from the AES40 Wind and Wave hindcast dataset compiled by Oceanweather Inc. The period covered by the dataset is 1954 to 2003. Grid Point 5467 (45.6250N, 59.1667W) was chosen because it is the closest to the centre of the Misaine Bank SEA Area. Following standard meteorological convention, wind direction refers to the direction from which the wind is blowing.

The prevailing wind direction during summer months is south to southwest. In winter the prevailing wind direction is west to northwest. Higher wind speeds are typically from the west or northwest direction and are associated with intense low pressure centres situated over the Gulf of St. Lawrence, western Newfoundland or southeastern Labrador.

Annual tables of wind speed versus direction and the corresponding wind rose diagrams are presented below (Table 3-1 and Figure 3-9). Monthly wind statistics are provided in Appendix A.



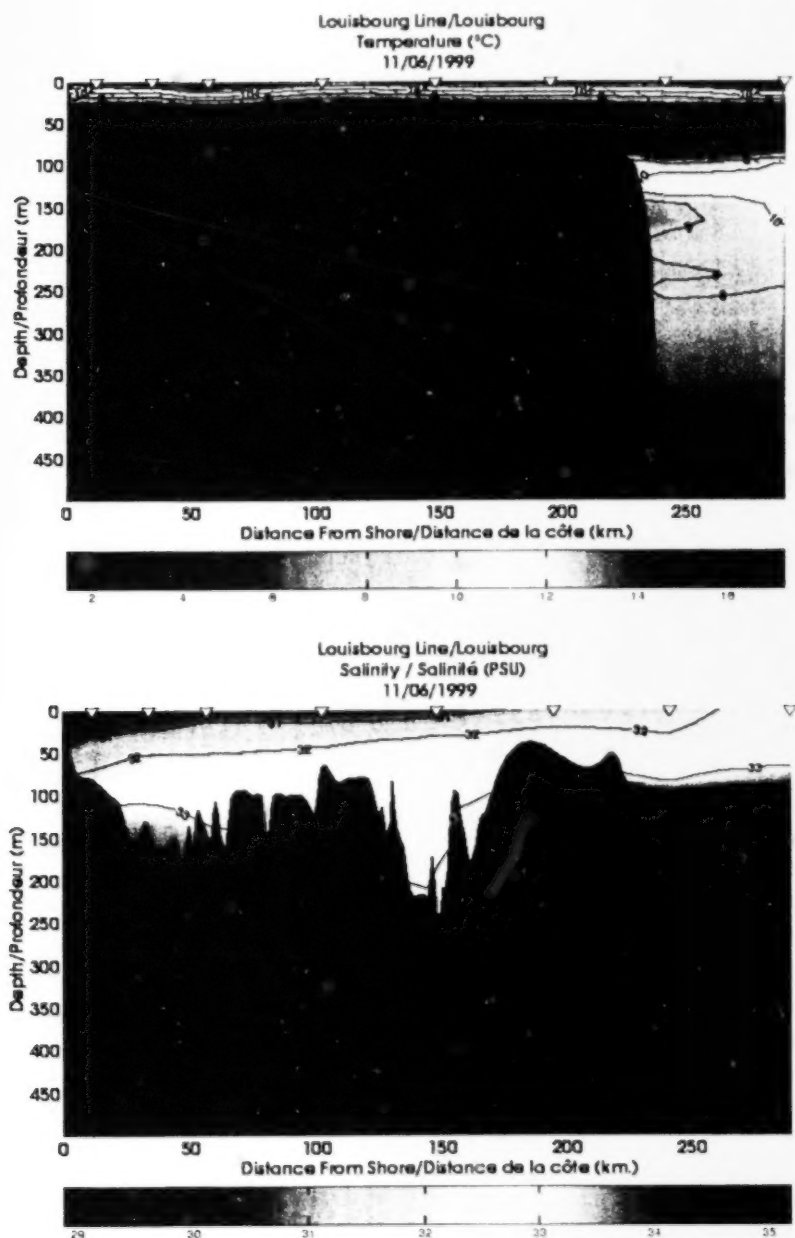


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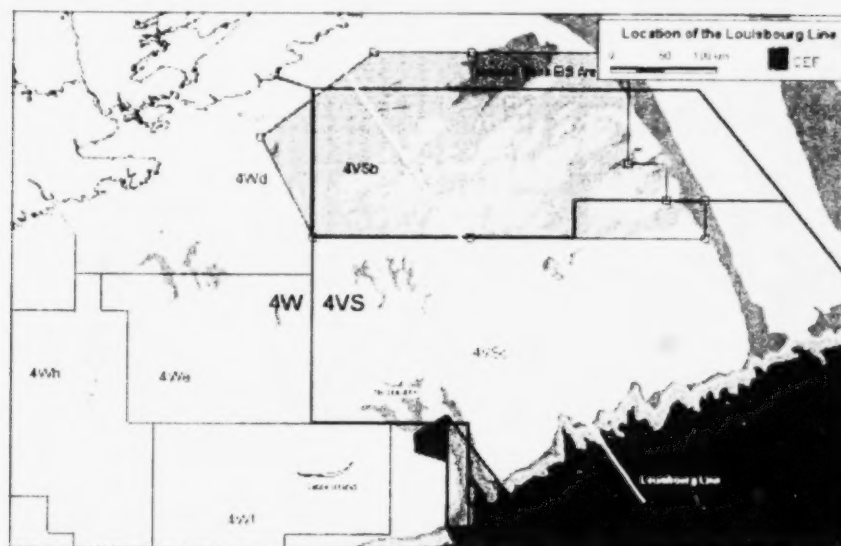


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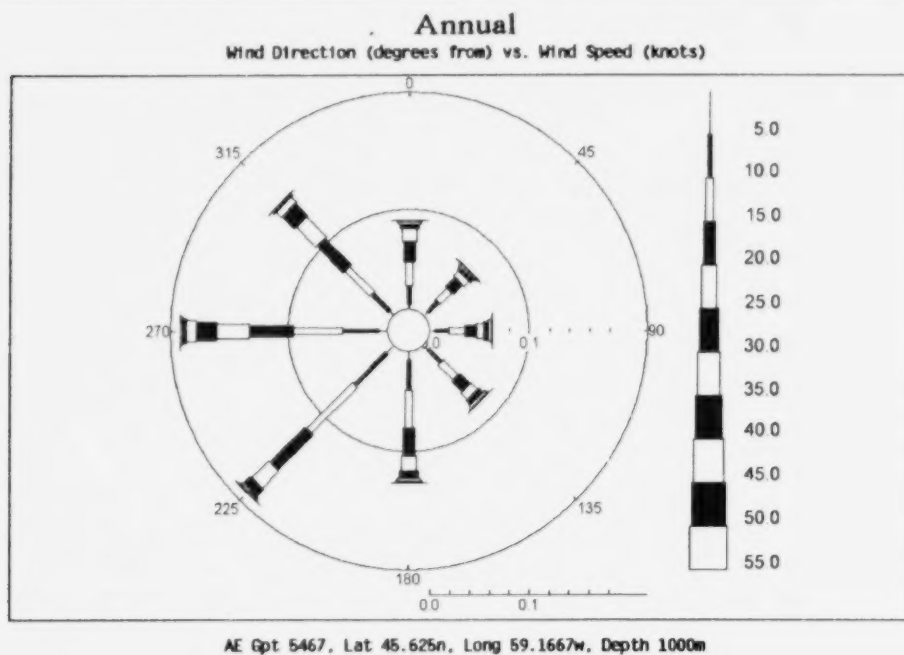


Figure 3-9: Annual Wind Direction vs. Wind Speed

Table 3-1

Annual Percentage Frequency Occurrence of Wind Speed by Direction

Source: AES40 Grid Point 5467 (45.6250N, 59.1667W) 1954 - 2003

	Wind Direction (blowing from)								Total
	NE	E	SE	S	SW	W	NW	N	
0 - <5	0.4	0.4	0.5	0.8	1.0	0.9	0.6	0.4	4.9
5 - <10	1.5	1.4	1.8	3.0	4.5	3.6	2.5	1.9	20.2
10 - <15	1.7	1.6	2.2	3.8	6.5	5.0	3.6	2.4	26.8
15 - <20	1.3	1.1	1.5	2.8	5.0	4.3	3.7	2.1	21.9
20 - <25	0.7	0.8	0.9	1.5	2.4	3.4	2.9	1.2	13.8
25 - <30	0.4	0.5	0.6	0.8	0.9	2.1	1.7	0.5	7.4
30 - <35	0.2	0.2	0.3	0.3	0.3	1.1	0.8	0.2	3.4
35 - <40	0.1	0.1	0.1	0.1	0.1	0.4	0.2	0.1	1.2
40 - <45	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.3
45 - <50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
50 - <55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	6.3	6.2	7.9	13.1	20.8	20.8	16.1	8.9	100.0

3.5 Waves

Wave statistics were generated from the AES40 Wind and Wave hindcast dataset compiled by Oceanweather Inc. The period covered by the dataset is 1954 to 2003. Grid Point 5467 (45.6250N, 59.1667W) was chosen because it is the closest to the centre of the Misaine Bank Environmental Assessment Area. Following standard oceanographic convention, wave direction refers to the direction to which the waves are traveling.

Most waves originate from the south through northwest (traveling in the north through southeast directions). This is directly related to the prevailing wind directions discussed in the previous section. Higher waves generally originate from the southerly through westerly directions (traveling north through east). High waves from the west can be attributed to the high wind speeds from this direction, while high waves from the south and southwest are the result of the predominant flow in the western North Atlantic combined with long 'fetch' or length of the wave generation area in these directions.

An annual table of significant wave height versus primary wave direction (Table 3-2) and the corresponding wave rose diagrams (Figure 3-10) are presented below. Monthly statistics are provided in Appendix A.

Table 3-2

Annual Percentage Frequency Occurrence of Wave Height by Direction

Source: AES40 Grid Point 5467 (45.6250N, 59.1667W) 1954 - 2003

Significant Wave Height (metres)	Wave Direction (travelling <u>to</u>)									
	NE	E	SE	S	SW	W	NW	N	Total	
	0.0 - <1.0	2.7	1.7	1.1	0.8	0.7	0.8	1.1	2.2	11.0
	1.0 - <2.0	12.4	7.9	6.1	4.1	2.7	2.5	3.6	7.5	46.9
	2.0 - <3.0	5.0	5.1	4.0	2.3	1.6	1.5	1.7	2.9	24.1
	3.0 - <4.0	2.0	2.8	1.7	0.9	0.7	0.7	0.8	1.2	10.8
	4.0 - <5.0	0.9	1.1	0.5	0.3	0.3	0.3	0.3	0.6	4.4
	5.0 - <6.0	0.4	0.4	0.2	0.1	0.1	0.1	0.2	0.3	1.7
	6.0 - <7.0	0.2	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.7
	7.0 - <8.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2
	8.0 - <9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	9.0 - <10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	10.0 - <11.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.0 - <12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Total	23.5	19.2	13.7	8.5	6.3	6.1	7.8	14.8	100.0	



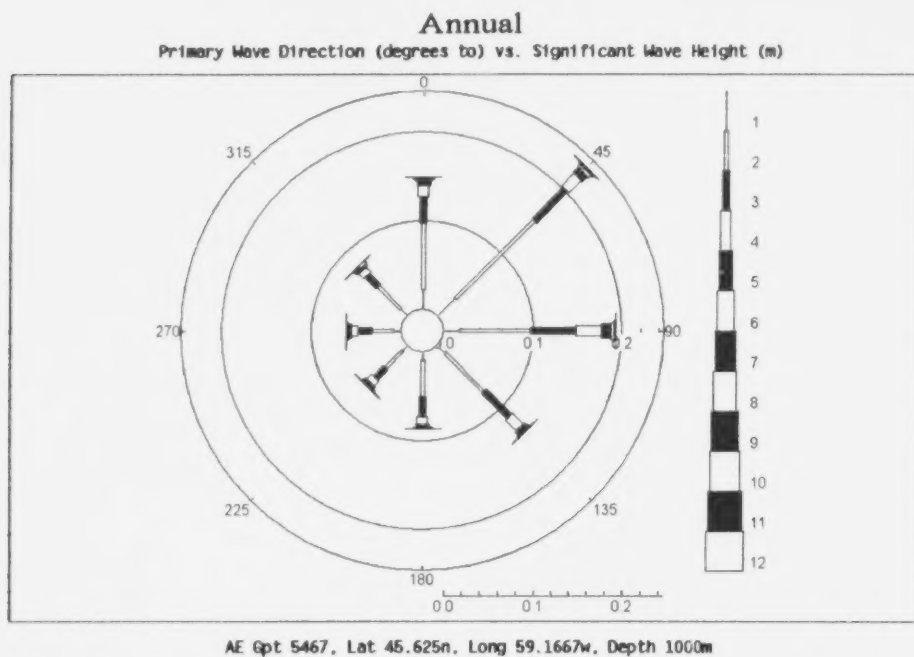


Figure 3-10: Annual Primary Wave Direction vs. Significant Wave Height

3.6 Noise

The generic seismic assessment provides a comparison of ambient and seismic noise levels (Davis et al. 1998). The assessment modeled sound propagation over Sable Island Bank in four directions from Sable Island. The modeling showed that noise from typical airgun arrays would diminish to values of 150 to 160 dB within 4.5 to 14.5 km, depending on bottom type, water depth, and sea state.

The ambient noise field off the Scotian Shelf has been the subject of several studies. Ambient open ocean noise at Sea State 4 (wind speed 18-20 knots/hour; significant wave heights 1.8-2.3 m) ranges from 75 to 90 dB between 100 and 1000 Hz. In contrast, information available on underwater noise within the surf zone predicts noise levels would be between 110 – 120 dB in the 100-1000 Hz band at a distance of 200 m from the surf under winds of 25-35 knots (Wilson et al. 1985).

Noise levels at 20 Hz are strongly influenced by vocalizing finback whales when they are in the area. From 50 to 100-200 Hz, noise is dominated by shipping. Above 200 Hz, the noise field is dominated by wind stress on the ocean surface.

Figure 3-11 shows the vertical distribution of the speed of sound in Misaine Bank for March and August, computed from BIO's Climatic Hydrographic Database. These two months represent the extremes of the hydrographic variability in the area, occurring during late winter and late summer.

According to Figure 3-10, there will be favourable conditions for the propagation of acoustic signals within the entire water column throughout the year. During the cold months, the temperature inversion guarantees the existence of a surface duct, since the lowest speeds of sound will be near the surface. Accordingly, acoustic rays will bounce from the surface and eventually bend back to it due to the prevailing sound speed gradient.

During the warm season, there will be a speed minimum around 75 m. This depth would serve as the axis of an acoustic channel along which sound would propagate long distances.

Due to the relatively shallow depths of the Misaine Bank, the sound signals are likely to be channeled in a waveguide bounded above by the surface and below by the ocean bottom. Therefore, the irregular character of the ocean floor at Misaine Bank (extensively incised by channels and canyons) will interfere with the smooth propagation of the acoustic signals, generating a great deal of reflection and scattering which, along with the horizontal changes in condition of the ocean floor (in Misaine Bank, areas of gravel bottom alternate with areas covered mostly by sand with gravel mixed in) will make the collection and interpretation of acoustic seismic signals a challenging task.



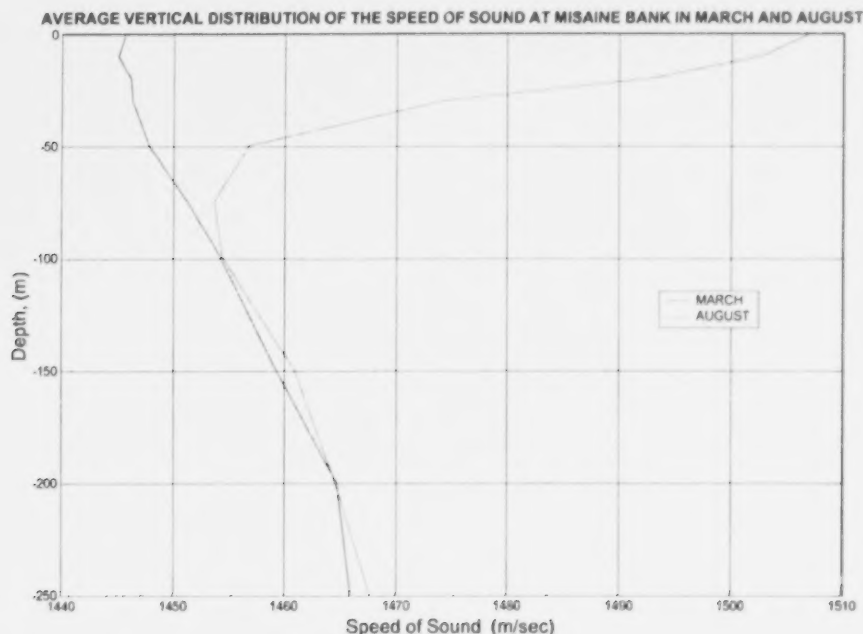


Figure 3-11: Sound Speed Profiles in Misaine Bank Computed from Mean Temperature and Salinity

4 BIOLOGICAL ENVIRONMENT

Several recent papers focus on the ecosystems of the Scotian Shelf including: O'Boyle (2000), Coffen-Smout et al. (2001), Breeze et al. (2002), Zwanenburg et al. (2002), DFO (2003), and Breeze and Maris Consulting (2004).

4.1 Primary Productivity

Primary productivity in the Misaine Bank area is supported by nutrients carried from the Gulf of St. Lawrence and from deeper waters of the Laurentian Channel. Phytoplankton biomass, reflecting primary productivity, has been increasing on the eastern Scotian Shelf since the 1970s and 1980s (DFO 2005). The SEA area shows seasonal fluctuations in phytoplankton concentrations similar to those found over much of the Scotian Shelf: a large spring bloom dominated by diatoms, and a smaller fall bloom dominated by dinoflagellates.

The Misaine SEA area supports a higher plant biomass than the rest of the Scotian Shelf at certain times of the year. This biomass, however, is not as great as in certain high productivity areas of the shelf such as southwest Nova Scotia, and areas near the coast.



Chlorophyll *a*, an indicator of plant biomass and potential for primary productivity, may be more sustained than in other parts of the shelf (Breeze et al. 2002).

4.2 Zooplankton

Zooplankton communities on the northern Scotian Shelf are dominated by calanoid copepods, in particular *Calanus* species. Deeper waters of the study area on the shelf, particularly in the basins, support krill, primarily the carnivorous/herbivorous *Meganictyphanes norvegica*, and the phytoplankton-feeding *Thysanoessa* spp. Krill are known to be important in the deep channels and basins that border Misaine; in basins around the margin (e.g., St. Anns); and in the Laurentian Channel adjacent to the SEA area (Breeze et al. 2002; Sameoto and Cochrane 1996). Euphausiids migrate vertically to surface waters at night and descend to deep water (> 200 m) in the basins during the day. The abundance of copepods and euphausiids on the Eastern Scotian Shelf has been increasing since the late 1990s (DFO 2005), but euphausiid biomass is lower than for copepods. Higher concentrations of zooplankton have been found in the SEA study area than on the Scotian Shelf as a whole (O'Boyle et al. 1984; Breeze et al. 2002). Zooplankton biomass peaks in May-June and in the autumn, following peaks in phytoplankton biomass (Breeze et al. 2002).

Much of the SEA area is deeper than the spring/summer mixed layer where primary production is concentrated. Zooplankton dominate the plankton community in the deeper waters, consuming more of the overall production than in shallower areas. Macrozooplankton tend to be more important in these deeper areas.

4.3 Benthic Communities

In terms of benthic studies, coverage within the Misaine Bank SEA area is poor. The benthic data is largely from photographs of the ocean bottom.

Benthic communities in the SEA area are not likely to be particularly productive for most non-commercial species because of the deep waters and cold temperatures on much of Misaine Bank. Organic matter produced in the water column is used extensively by zooplankton and so few nutrients reach the seabed. Photos of the Misaine Bank seabed (Josenhans et al. 2004) show communities of surface-deposit-feeding polychaetes and amphipods. Deeper silt/clay bottoms likely support burrowing anemones, as well as northern shrimp and snow crab, which occur on clay bottoms in the channels and depressions.

The benthic community is likely to support suspension feeders only on eastern Banquereau Bank, at the far southeast corner of the SEA area. Banquereau supports populations of the suspension-feeding Stimpson's Surfclam (*Mactromeris polynyma*) and northern propeller clams (*Cyrtodaria siliqua*).



Along the margin of the study area bordering the Laurentian Channel, glacial till and attendant cobble and boulders could support shelf edge benthic communities of attached fauna, such as anemones and deep sea corals. On the Stone Fence, an area of till 61 km southeast of the study area, deep sea corals occur at depths below 300 metres to approximately 1000 metres (MacIsaac et al. 2001; Jacques Whitford Environment 2003).

The intensive shrimp and snow crab fisheries in the SEA area is associated with an expansion of low temperatures over the Eastern Scotian Shelf in the 1980s and 1990s (Zwanenburg et al. 2002). Temperatures have returned to more average levels, and production in these fisheries may also be returning to those existing earlier. The lower temperatures were also associated with an increase in abundance of several fish species, including capelin, turbot, and sand lance. Low numbers of cod, a major predator, may also have contributed to the increases in population sizes of macroinvertebrates (Zwanenburg 2003).

4.4 Commercial Marine Invertebrates

Northern shrimp (*Pandalus borealis*), snow crab (*Chionoecetes opilio*), lobster (*Homarus americanus*), Jonah crab (*Cancer borealis*), and rock crab (*Cancer irroratus*) are commercial invertebrate species occurring within and around the study area.

4.4.1 Snow Crab

Snow crab is a significant component of the Scotian Shelf biomass, including the SEA area. Snow crabs occur at depths between 60 and 300 metres, preferring habitat with soft, mud bottoms, in water ranging from -1°C to 6°C . Smaller crabs favour rockier habitats that can provide more shelter. Snow crabs are a food source for groundfish such as cod, halibut, and American plaice, and are also preyed upon by skate, seals, and other crabs. They feed on fish, shrimp, and other small benthic invertebrates (DFO 2005).

Female snow crabs produce their eggs in the spring. Between 35 000 and 46 000 eggs are normally fertilized and carried under the female's abdomen for up to two years. Eggs hatch between spring and early summer; larvae are pelagic, feeding on plankton, until autumn or early winter when they settle to the ocean floor. Immature snow crabs moult twice a year until their fifth instar, after which moulting occurs once per year until a final moult. For males, the terminal moult occurs between instars 9 and 14, and for females, between 9 and 11. Sexual maturity can occur by the ninth instar and legal commercial fishery size is normally reached by the twelfth instar (8-9 years). After terminal moult, females can reproduce two to three times over a period of five to six years, depending upon environmental conditions. Current recruitment levels are below average on the Scotian Shelf (DFO 2005).



4.4.2 Northern Shrimp

Northern shrimp have a large biomass on the Scotian Shelf and short-term prospects the fishery remain positive. Shrimp prefer waters between 2°C and 6°C, with soft, muddy bottoms, at depths of 10 to 500 metres. Concentrations of shrimp occur in deep offshore holes on the Eastern Scotian Shelf. These include the Louisbourg Hole, which is located in the SEA area, and smaller holes located mostly south of Misaine Bank (DFO 2004a).

During the day, shrimp feed on detritus, polychaete worms, and small crustaceans on the ocean bottom. At night, shrimp rise through the water column to feed on crustaceans such as copepods, amphipods, and euphausiids. They are prey to groundfish such as cod, silver hake, redfish, Atlantic halibut, and other flatfish.

On the Scotian Shelf, northern shrimp first mature as males at the age of two and, after four years, change sex to become females. Total lifespan is approximately five to eight years. Spawning occurs between late summer and early fall. Fertilized eggs are attached to the female's abdomen during the incubation period that lasts approximately eight months. After this period, eggs hatch and the pelagic larvae spend three to four months feeding near the water's surface before settling to the bottom. (DFO 2004a).

4.4.3 Other Species

Nova Scotia represents the northern extent of east coast Jonah crab distribution. In Nova Scotia, Jonah crabs occur primarily at depths of 50 – 300 m, in water temperatures of 8°C to 14°C (DFO 2000a). These crabs are fished west of the study area. Although Jonah crabs are not an important commercial species on Misaine, they are most likely present (DFO 2000a).

Rock crabs are more widely distributed and are found from Labrador to South Carolina in shallow waters less than 20 m deep and mainly on sandy bottoms (DFO 2000b). On Misaine Bank, rock crabs are not commonly fished, but are a bycatch species (DFO 2000b).

Lobsters are most common in coastal waters, but they can also be found along the outer edge of the continental shelf from Sable Island to North Carolina. Coastal lobster fisheries exist close to the study area (LFA's 31A, 30, 27), and lobster may also occur within the Misaine SEA area in low numbers. Lobsters migrate seasonally moving to more shallow water in the summer and deeper in the winter (DFO 2004f).

4.5 Marine Fish

Fish are the most abundant and diverse group of vertebrates in the ocean, with 538 species recorded in the Canadian Atlantic Region alone. The marine fishes likely to be found in Nova Scotia's coastal waters may be divided into five groups: small fishes of estuaries and tidal inlets, groundfish, pelagic species, mesopelagic species, and exotic



warm-water and eastern-arctic species. The shallow-water environments offer more opportunities for specialization and therefore have high species diversity. Further offshore, the species diversity is lower but the biomass is high.

A number of marine fish are commonly associated with the study area. Major commercial species include Atlantic cod (*Gadus morhua*), Atlantic halibut (*Hippoglossus hippoglossus*), Greenland halibut (*Reinhardtius hippoglossoides*), haddock (*Melanogrammus aeglefinus*), pollock (*Pollachius virens*), redfish (*Sebastes* sp.), flounder (sp.), American plaice (*Hippoglossoides platessoides*), white hake (*Urophycis tenuis*), skate (*Raja* sp.), Atlantic herring (*Clupea harengus*), and Atlantic mackerel (*Scomber scombrus*). Sand lance, (*Ammodytes americanus*), ocean pout (*Macrozoarces americanus*) and Atlantic sea raven (*Hemitripterus americanus*) are some of the more common non-commercial species.

4.5.1 Seasonal Distributions

During the winter months most groundfish species are found in deeper warmer waters along bank edges and adjoining basins. These include cod, American plaice, and witch and yellowtail flounder. Some flounder and most skate (*Raja* sp.) remain on the banks throughout the winter. As surface waters warm in the spring, groundfish move into shallower water on the banks.

In summer, most groundfish species disperse over the tops of the banks. These include Atlantic cod, silver hake, American plaice, wolffish and halibut. Porbeagle (*Lamna nasus*) and dogfish sharks (*Squalus* sp.) are found across the Shelf. Squid (*Illex illecebrosus*) are widely distributed, with some concentrations along the Shelf Edge.

In early autumn, migratory summer residents move offshore and south. Atlantic mackerel move through the area to wintering grounds along the Shelf beginning in October. Tuna and swordfish have left the Shelf by November. Squid move offshore toward the Gulf Stream in October and November. In late autumn, most groundfish species move into deeper waters along the bank edges and the basins. Spiny dogfish migrate out of the area in November and December.

4.5.2 Commercial Groundfish

Atlantic cod are found in cool-temperature to subarctic waters from the inshore to the edge of the continental shelf. They occur from depths of 460 m to the surface in temperatures between 3°C and 8°C, but they are most commonly associated with the bottom. Cod feed on copepods, amphipods, barnacle larva, and other small crustaceans. As juvenile cod grow they continue to eat crustaceans such as euphausiids, mysids, shrimp, small lobsters, spider crabs and hermit crabs. Young adult and older cod eat mainly fish of any species they can catch, including other cod. Cod eggs are buoyant, pelagic, spherical, and are about 1.2 – 1.6 mm in diameter (Scott and Scott 1988; DFO 2003b).



Winter skate live on sandy or gravel bottom. They prefer water shallower than 110 m, but they have been caught at depths of up to 370 m. This species is temperature tolerant, and has been found at temperature between -1.2°C and 15°C . Polychaetes and amphipods are their primary food, but they also eat fish, isopods, and decapods. Sand lance, also common on Misaine Bank, can be a major part of their diet. Skate eggs are large; the case is 5.5 to 8.6 cm long by 3.5 to 5.2 cm wide (Scott and Scott 1988; DFO 2002a).

Flatfish are bottom dwelling fish that have both eyes on one side of their head. The American plaice and yellowtail flounder are two commercially important flatfish in the study area. American plaice generally live at depths between 70 and 270 m, but they have been found from as deep as 700 m. They are a coldwater species that prefer temperatures just below 0°C to 1.5°C , but they can tolerate water as warm as 13°C . They eat polychaetes, echinoderms, molluscs, crustaceans, and fish.

Yellowtail flounder are also a cold-water fish. They prefer sand or sand and mud bottoms at depths between 30 and 365 m, but prefer depths less than 90 m. Yellowtail are found in waters between 2°C to 6°C , but prefer water between $3.1 - 4.8^{\circ}\text{C}$. Yellowtail flounder feed mainly on polychaete worms and amphipods, but also consume other crustaceans such as shrimp, cumaceans, isopods and other small invertebrates (Scott and Scott 1988; DFO 2002b).

Witch flounder are a long-lived, slow growing species. They live in depths between 50 – 300 m and have been recorded as deep as 1570 m, at preferred temperatures between 2°C and 6°C . They are often found on the Shelf slope and muddy bottom, and prefer deep holes and channels. The spawn on the Shelf between May and October with peak activity in the summer. Witch flounder eat primarily worms and other benthic invertebrates (DFO 2002c).

Atlantic halibut are the largest of the flatfish and they range widely over all of Canada's East Coast fishing areas. They prefer depths of between 200 and 500 m and temperatures near 5°C , but not below 2.5°C . Young halibut are found in shallower water and as the fish mature they migrate to deeper waters. Until a halibut reaches approximately 30 cm, it feeds almost exclusively on invertebrates, mainly crustaceans and marine annelids. Prey includes both invertebrates and fish when a halibut reaches between 30 and 80 cm length. Large halibut (over 80 cm) eat mainly fish. Halibut spawn from late winter until early spring in deep waters. Halibut eggs are 3.0 mm spheres that are neutrally buoyant but sink as development progresses (Scott and Scott 1988; DFO 2001a).

Redfish comprise three species of the genus *Sebastes*. Redfish live near and above the bottom and eat crustaceans, copepods, amphipods and euphausiids as young fish. As they increase in size, other fish species become more important in their diet. All three species of redfish are ovoviviparous, meaning they give birth to live young. While a mature cod may release 2 million eggs, a mature redfish will extrude only 30 000 eggs and hatch and release less than 15,000 young.



The three species of *Sebastes* in the study area are the Acadian redfish, golden redfish, and deepwater redfish. They remain on or near the bottom in the day, rising to feed at night. The deepwater redfish (*Sebastes mentella*) lives in depths from 350 – 700 m, but rises higher in the water column than the other two species. The golden redfish (*Sebastes marinus*) lives at intermediate depths. Acadian redfish (*Sebastes fasciatus*) is the shallowest water redfish species, living in water as shallow as a few metres and as deep as 600 m. These redfish prefer a temperature range from 2.8 to 8.3 °C (Scott and Scott 1988; DFO 2002c).

4.5.3 Large Pelagics

Tuna and swordfish, the major large pelagic species, are uncommon within the Misaine SEA area.

Porbeagle Sharks (*Lamna nasus*) can be considered as a pelagic, epipelagic, or littoral shark. They are most common offshore on continental shelves, but they also move into coastal areas. Porbeagle sharks can grow to over 3 m and live for 30 years. Porbeagle eat mainly small fish, such as herring, gaspereau, and mackerel, but also feed on cod, white and red hake, cusk, haddock, and squid. They prefer cool to cold water and are usually found in water between 6°C and 16°C. Porbeagle sharks are ovoviparous, with young extruded at a length of 60 – 75 cm in late summer (Scott and Scott 1988; DFO 2001b).

4.5.4 Pelagic and Estuarial

Capelin have become relatively common within the Misaine SEA area in recent years. They are a cold deep-water species that inhabit the Atlantic ocean's offshore banks and coastal areas. They migrate inshore in early June and spawn on beaches. Capelin eat planktonic organisms such as euphasiids (the main staple of their diet), copepods, amphipods and other planktonic invertebrates.

4.6 Eggs, Larvae, & Spawning

Avoidance of important spawning areas at potential spawning times by seismic survey operations has been identified as an important measure to minimize potential ecosystem impacts (Thomson et al. 2001; DFO 2004b).

Spawning areas and times can be identified by two main sources: data from the Scotian Shelf Ichthyoplankton Program (SSIP) and scientific literature based upon specific research. The SSIP was a comprehensive egg and larval survey of the Scotian Shelf conducted from 1978 to 1982.

In this study, two sources of SSIP data were used. First, data for stations falling within or near the Misaine SEA area were extracted from a subset of the SSIP dataset comprising double oblique bongo tows. Various gear types were used in the survey in addition to oblique bongo tows. These included tows with surface neuston nets, and stepped and



surface bongo tows. Oblique bongo data was used for the subset because it provided a good overview of the organisms sampled, provided a simpler data structure, and was a more manageable size. The second data set was a series of maps processed by DFO and produced for the Electronic Atlas of Ichthyoplankton on the Scotian Shelf of North America (EAISSNA). These maps (Stewart et al. 2003) cover all gear types by month for all species and species combinations.

4.6.1 Methodology

Seasonal distributions of eggs and larvae are described for two reasons. First, eggs and larvae can be damaged or killed if within about 5 metres of firing airguns (Davis et al. 1998). Second, the distribution of eggs, especially early stage eggs, is a good indication of the timing and location of spawning.

The first step in the analysis was identifying the species and timing associated with eggs found within the Misaine SEA area. SSIP stations falling within or close to the Misaine SEA area (Figure 4-1) were extracted from the oblique bongo database and numbers summarized by species and month (Table 4-1). Numbers of eggs and larvae were adjusted for volume of water strained and reported as numbers per m^3 .

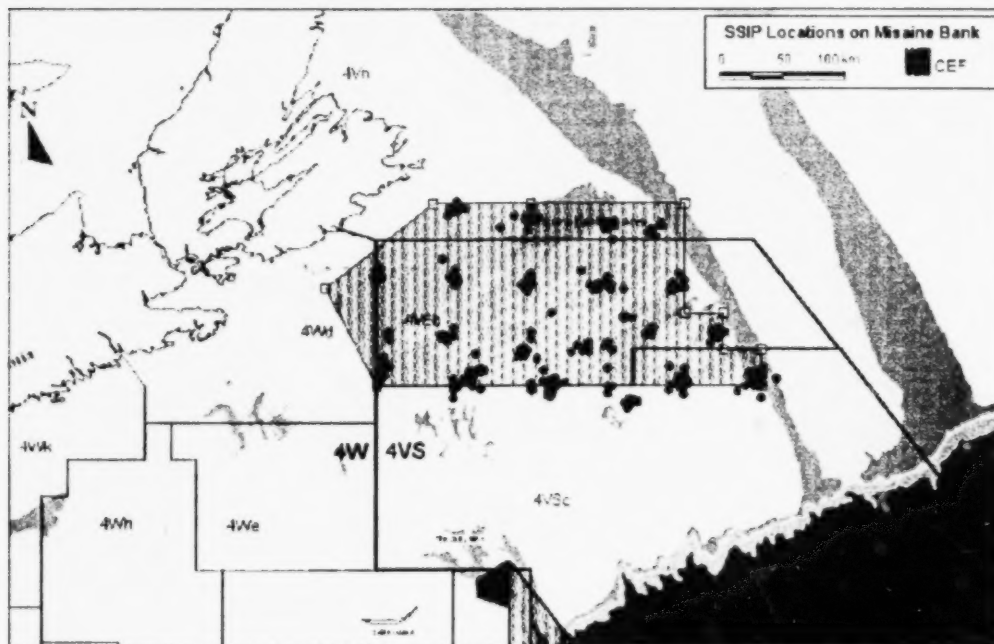


Figure 4-1: SSIP Stations within the Misaine SEA Area

Additional information on spawning was obtained for these species from the literature and summarized. Finally, the maps of monthly egg distributions for all SSIP gear types for the Scotian Shelf provided in Stewart (2003) were reviewed to determine the relative importance of egg abundance within the Misaine SEA area in relation to the broader



Scotian Shelf. For example, peak egg counts could be located in areas outside the Misaine SEA area. This would suggest that spawning is more likely located outside the SEA area, and eggs are simply carried into the area where they were sampled.

4.6.2 Eggs and Larvae from SSIP Oblique Bongo Tows

Average numbers of eggs per sampling period are summarized in Table 4-1 by species and month. Numbers of larvae from the same dataset are provided in Appendix A.

Table 4-1: Average Numbers of Fish Eggs by Month within the Misaine SEA Area (individuals/m³)

Species	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Fish unknown	0.000	0.000	0.000	0.000	0.017	0.000	0.000	0.000	0.000	0.000	0.000	0.000
COD	0.001	0.000	0.000	0.000	0.033	0.001	0.000	0.000	0.000	0.000	0.000	0.001
PLAICE	0.000	0.000	0.017	0.000	0.523	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MACKEREL	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
WITCH	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.001	0.000	0.000	0.000	0.000
ROCKLING	0.000	0.000	0.000	0.000	0.000	0.001	0.007	0.005	0.001	0.000	0.000	0.000
YELLTAIL	0.000	0.000	0.000	0.000	0.016	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CUNNER	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000
CUSK	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000
HAKRBFWP	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.006	0.001	0.000	0.000	0.000
COD_HAK	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
SILVHAKE	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.004	0.000	0.002	0.000	0.000
CODHADWF	0.000	0.000	0.002	0.000	0.219	0.009	0.003	0.006	0.018	0.000	0.001	0.004
CUSKMACK	0.000	0.000	0.000	0.000	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000
CUNYTAIL	0.000	0.000	0.000	0.000	0.124	0.019	0.000	0.008	0.001	0.000	0.000	0.000
POLLOCK	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.003
TOTAL	0.001	0.000	0.019	0.000	0.940	0.032	0.013	0.031	0.022	0.002	0.002	0.008

Some eggs can be identified only to a species group at early stages of development. For example, HAKRBFWP refers to hake and flounder eggs, whereas CODHADWF refers to a possible mix of cod, haddock and witch flounder.

This SSIP dataset indicates that May is by far the period of peak egg abundance within the Misaine SEA area (Figure 4-2). During May, eggs of Atlantic cod, American plaice, witch and yellowtail flounder, silver hake, cusk/mackerel, cunner/yellowtail flounder, and pollock are found. Rockling is the only species with eggs found only during months other than May, and the numbers of eggs are comparatively low. Cod, plaice and yellowtail flounder are the only species for which relatively high numbers of eggs were reported. The scientific literature was examined to determine if spawning was likely to occur within the Misaine SEA area for these three species.



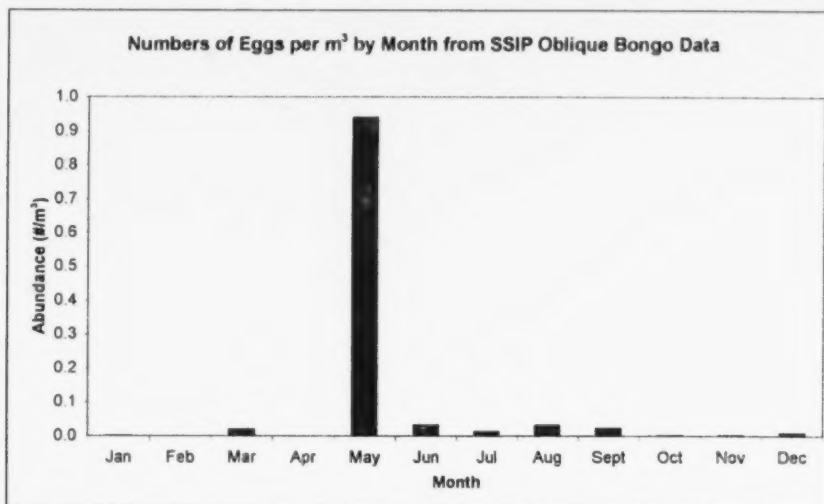


Figure 4-2: Monthly Abundance of eggs within the Misaine SEA Area from an SSIP Dataset

4.6.3 Literature Reports of Spawning

The eggs of cod, American plaice and yellowtail flounder are all buoyant and found on or near the surface of the ocean early in development (Scott and Scott 1988).

Precise spawning locations for cod have been difficult to identify because a number of groups spawn widely across the Scotian Shelf at different times of the year (Scott and Scott 1988). Recent stock status reports by DFO consider four general populations of cod. These include Western/Sable and Banquereau populations, smaller Middle and Canso Bank populations, and coastal spawning groups (DFO 2003b). Recent research vessel surveys indicate that spawning biomass and cod recruitment remains at historically low levels. Spatial distribution of sample catches conducted within the Misaine SEA area show autumn aggregations towards the inshore, suggesting the Misaine cod may be part of the coastal population.

American plaice spawn on the Scotian Shelf from winter to early summer, with peak spawning activity in the spring. Most spawning occurs within 90 metres water depth and all within 180 metres (Scott and Scott 1988). Spawning is thought to occur across the entire Shelf to the Shelf Edge, with highest egg concentrations on the southeastern Shelf from the Laurentian Channel to Emerald Bank (Breeze et al. 2002).

Yellowtail flounder spawn throughout the year to depths of 90 m. The largest spawning concentrations occur in July on Western Bank and southern Sable Island Bank (Scott and Scott 1988). Spawning is also reported on Banquereau, Sable Island, Western, Brown's, Emerald and Roseway Banks, but not Misaine Bank (Breeze et al. 2002).



4.6.4 EAISNA Maps of SSIP Data

The Maritime populations of Atlantic cod are low in abundance and classified as a species of concern under COSEWIC, as well as are listed under Schedule 3 of *SARA*. The potential status of the species under *SARA* increases the importance of minimizing any potential adverse impacts on spawning populations. Thus, EAISNA maps for all gear types were reviewed, with particular attention to surface tows because early stages of cod eggs are buoyant and tend to be found near or on the surface of the ocean (Scott and Scott 1988).

Figures 4-3 and 4-4 illustrate the Scotian Shelf wide distribution of early stage eggs of cod, haddock and witch flounder from double oblique bongo tows and surface bongo tows. These are considered to probably represent cod eggs because haddock are uncommon in this area and witch flounder eggs were only found in low numbers in the same survey data.

Figure 4-3 supports the extract of SSIP data used to prepare Table 4-1. It also illustrates that major egg concentrations are located at the entrance to Chedabucto Bay and on Banquereau Bank, but not within the Misaine SEA area.

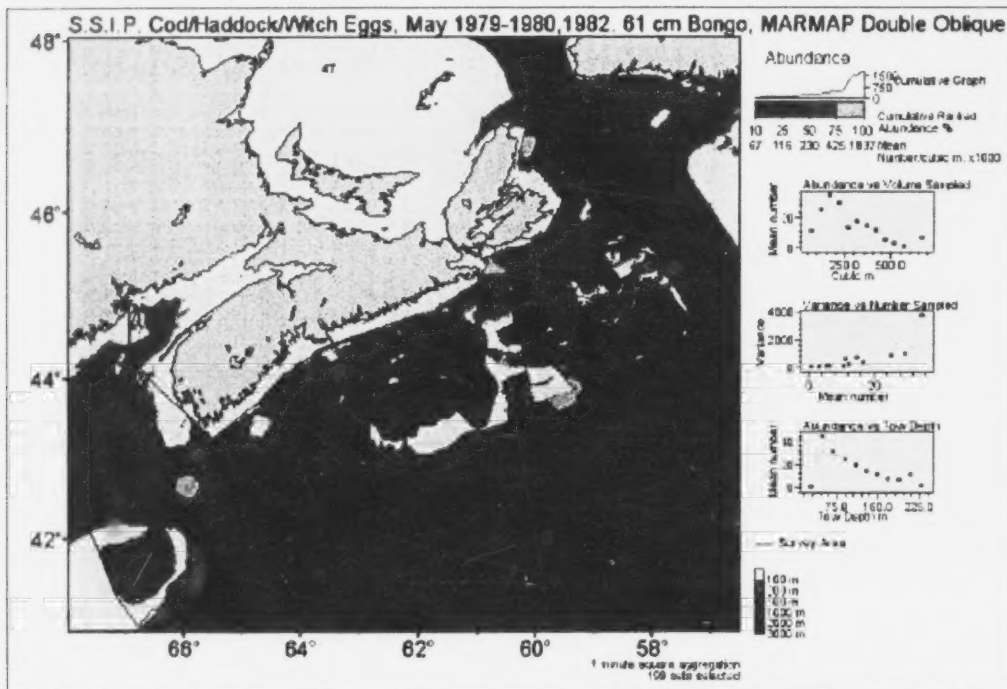


Figure 4-3: Concentrations of Probable Cod Eggs on the Scotian Shelf from SSIP Double Oblique Bongo Tows

Figure 4-4 shows a small possible concentration of eggs in the west of the study area, but this could be drift from either of the other two areas.

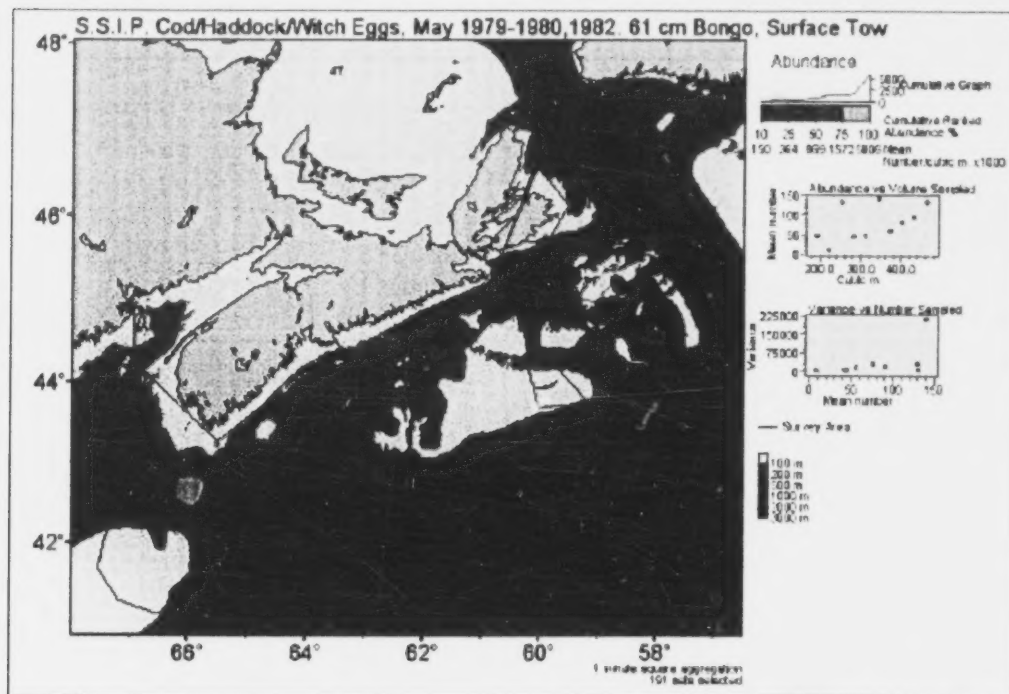


Figure 4-4: Concentrations of Probable Cod Eggs on the Scotian Shelf from SSIP Surface Bongo Tows

Similar to cod, yellowtail flounder eggs are concentrated in the Banquereau Bank area, potentially drifting northward into the Misaine SEA area (Figure 4-5).

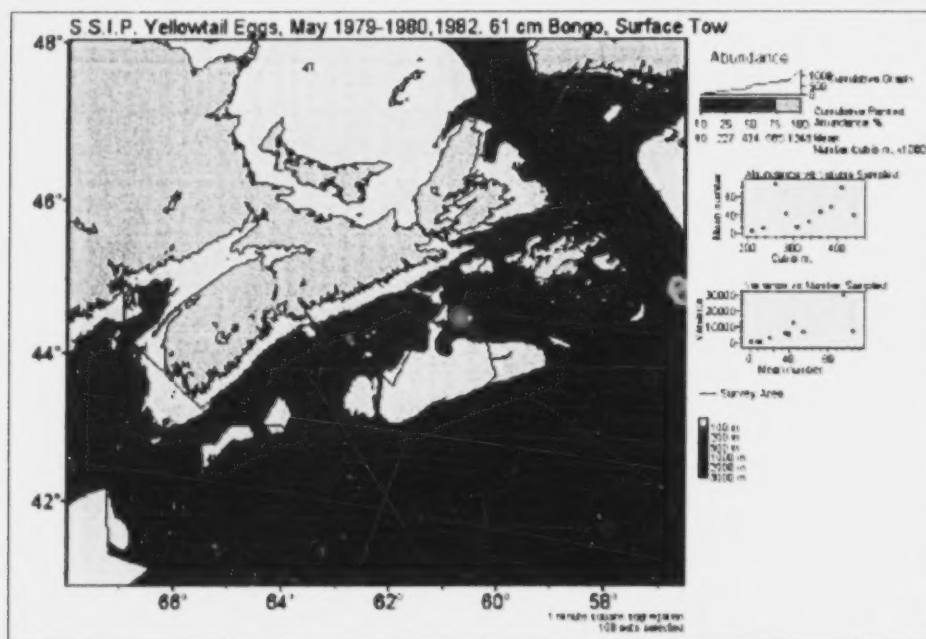


Figure 4-5: Concentrations of Yellowtail Eggs on the Scotian Shelf from SSIP Surface Bongo Tows

In contrast to cod and yellowtail, Figure 4-6 illustrates that American plaice eggs are concentrated within the Misaine SEA area and widely distributed.

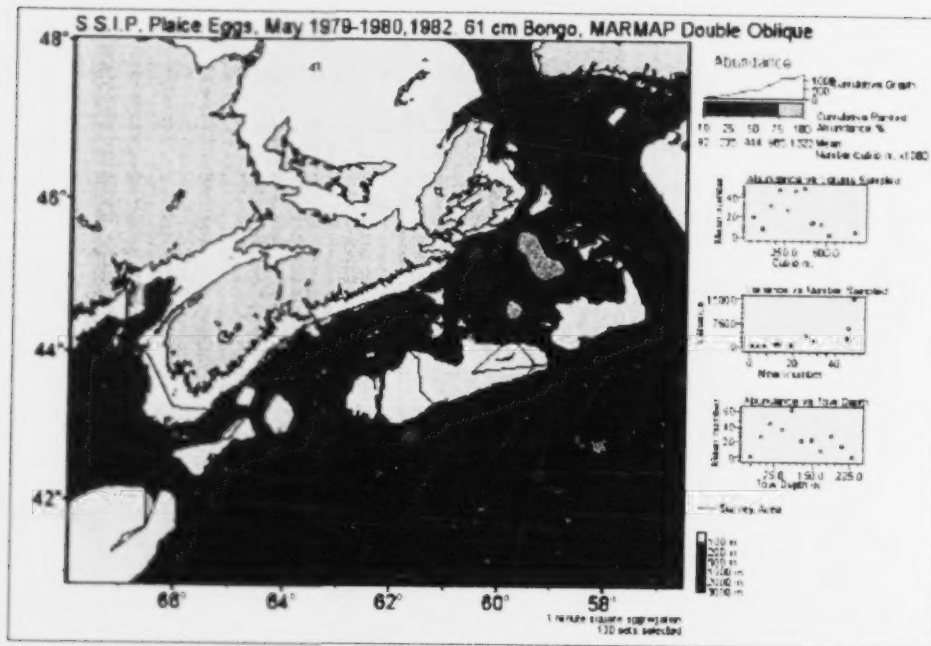


Figure 4-6: Concentrations of American Plaice Eggs on the Scotian Shelf from SSIP Surface Bongo Tows

Table 4-2 represents a summary of the potential for spawning to occur within the Misaine SEA area, and the occurrence of eggs and larvae, based on review of the literature and SSIP data.

Table 4-2: Occurrence of Eggs, Spawning and Larvae in the Misaine SEA Area

Species	Eggs Occurrence and Potential Spawning	Occurrence of Larvae
Atlantic cod	Spawning not identified in the literature, but may occur in May.	Some larval concentrations in August and September.
American plaice	Spawn on Misaine Bank from March to early June, highest concentrations in May	Some larvae present from May to November.
Sandlance	Eggs not reported in the SSIP data.	Larvae in low numbers from February to April, but larger from May to August.
Fourbeard Rockling	Low numbers of eggs in July to September	Small numbers of larvae found in July to November.
Cunner	No spawning identified or eggs found in SEA.	Low numbers of larvae in August and September.
Witch flounder	A few eggs in May and August, major spawning appears unlikely.	Larvae in low numbers in August and September.
Yellowtail flounder	Peak egg concentrations in SEA in May, but spawning appears more on Banquereau and Middle Banks	Larvae in low numbers in July and August

No evidence of spawning or egg concentrations was found in the literature or the SSIP data for pollock or wolffish, but small numbers of larvae were recorded in SSIP surveys within the Misaine SEA area.

4.7 Marine Mammals

Whales and seals are found throughout the study area, with particular concentrations along the Laurentian Channel. The seismic generic assessment provides a review of biology of marine mammals on the Scotian Shelf (Davis et al. 1998: pp 100-142), as well as specific information on hearing ranges, sensitivities for cetaceans in general (pp. 142-145), baleen whales (pp. 145-146), toothed whales (pp. 147-148) and seals (p. 148). Relevant information from this report is summarized below.

4.7.1 Cetaceans

Whales, dolphins and porpoises all belong to the order Cetacea, which has two sub-orders, odontocetes, or toothed whales, and mysticetes, baleen whales. The latter have hairy plates, or baleen, hanging from their upper jaws that filter plankton, krill and small fish (like sand lance or herring) out of the water.

Odontocetes include all dolphins, porpoises, beaked whales, sperm whales and a few others. Most toothed whales, except for the sperm whale, are much smaller than baleen whales, and feed mainly on fish and squid.



In general, distributions of cetaceans reflect the abundance and availability of favoured prey. The energy needs of the large whales are enormous; for example, the blue whale, which feeds solely on krill/euphausiids, needs to consume between two and four tonnes a day. Whales must find areas where their prey concentrate, which often tend to be areas of high productivity – upwellings, strong tidal currents, shelf edges, and the like.

The seismic class assessment provides a thorough review of biology of marine mammals on the Scotian Shelf (Davis et al. 1998: pp 100-142), as well as specific information on hearing ranges, sensitivities for cetaceans in general (pp. 142-145), baleen whales (pp. 145-146), and toothed whales (pp. 147-148).

Table 4-3 summarizes the species known to occur on the Scotian Shelf and Slope, with an estimate of how likely they might be to occur in the Misaine SEA area.



Table 4-3: Marine Mammal Species that Occur on the Scotian Shelf

Common Name	Scientific Name	Likelihood of occurrence in study area
ORDER CETACEA (SUBORDER ODONTOCETI - Toothed Whales)		
Atlantic long-finned pilot whale	<i>Globicephala melaena</i>	high
Beluga Whale	<i>Delphinapterus leucas</i>	low
Blainville's beaked whale	<i>Mesoplodon densirostris</i>	low
Dwarf sperm whale	<i>Kogia simus</i>	low
Killer whale	<i>Orcinus orca</i>	very low
Northern bottlenose whale	<i>Hyperoodon ampullatus</i>	low
Pygmy sperm whale	<i>Kogia breviceps</i>	low
Sowerby's beaked whale	<i>Mesoplodon bidens</i>	medium
Sperm whale	<i>Physeter macrocephalus</i>	high
True's beaked whale	<i>Mesoplodon mirus</i>	low
Atlantic harbour porpoise	<i>Phocoena phocoena</i>	medium
Atlantic white-sided dolphin	<i>Lagenorhynchus acutus</i>	high
Bottlenose dolphin	<i>Tursiops truncatus</i>	low
Common dolphin	<i>Delphinus delphis</i>	high
Risso's dolphin	<i>Grampus griseus</i>	low
Striped dolphin	<i>Stenella caeruleoalba</i>	low
White-beaked dolphin	<i>Lagenorhynchus albirostris</i>	high
ORDER CETACEA (SUBORDER MYSTECETI - Baleen Whales)		
Blue whale	<i>Balaenoptera musculus</i>	high
Fin whale	<i>Balaenoptera physalus</i>	high
Humpback whale	<i>Megaptera novaeangliae</i>	high
Minke whale	<i>Balaenoptera acuterostrata</i>	high
Right whale	<i>Eubalaena glacialis</i>	low
Sei whale	<i>Balaenoptera borealis</i>	medium
ORDER CARNIVORA (FAMILY PHOCIDAE - Seals)		
Grey Seal	<i>Halichoerus grypus</i>	high
Harbour Seal	<i>Phoca vitulina</i>	medium
Harp Seal	<i>Phoca groenlandicus</i>	Low
Hooded Seal	<i>Cystophora cristata</i>	Low
Ringed Seal	<i>Phoca hispida</i>	Low

The distribution of marine mammals over the Scotian Shelf is poorly documented on both temporal and spatial scales. There are three main databases from which marine mammal distributions are derived:



- historical whale harvesting and sighting records from May to November 1966 to 1972 (Sutcliffe and Brodie 1977);
- the University of Rhode Island cetacean assessment program (CETAP 1982); and
- offshore observed records collected during seismic operations (OGOP 2000; 2001).

The Sutcliffe and Brodie (1977) data, together with numerous other databases, were replotted and made available in a series of charts, by month and species (Kenney 1994). Nonetheless, whaling data is limited by poor spatial and temporal coverage. Few records exist for the eastern Scotian Shelf, including the Misaine SEA area, or in the winter.

Researchers at Dalhousie University have conducted numerous cruises on the Scotian Shelf since 1988 and compiled a large database of sightings primarily in and near the Gully (Whitehead et al. 1997). Corresponding deep water regions along the edge of the Laurentian Channel have not been studied to the same extent.

Whale distributions off Nova Scotia are known to change seasonally. Most northern hemisphere baleen whales tend to feed in higher latitudes in summer, and move south for the winter; mating and calving usually take place on the winter grounds.

The Laurentian Channel and the Shelf Edge are migration routes for whales moving in and out of the Gulf of St. Lawrence, an important summer feeding ground for blue whales, fins, humpbacks, and numerous other baleen and toothed species, driven by the Gulf's high plankton productivity.

The location of the Misaine SEA, on the eastern Shelf Edge adjacent to the Laurentian Channel, means that species moving in and out of the Gulf would cross through it, or move alongside it. Whale movements in the Gulf are comparatively well documented, and species occurrence in the Gulf can serve as a proxy for those likely to transit the Misaine area.

Table 4-4 summarizes distribution and prey of cetaceans rated highly likely to occur in the Misaine SEA area.

Table 4-4: Summary of the Distribution and Primary Prey of Toothed and Baleen Whales Probably Common in the Misaine Area

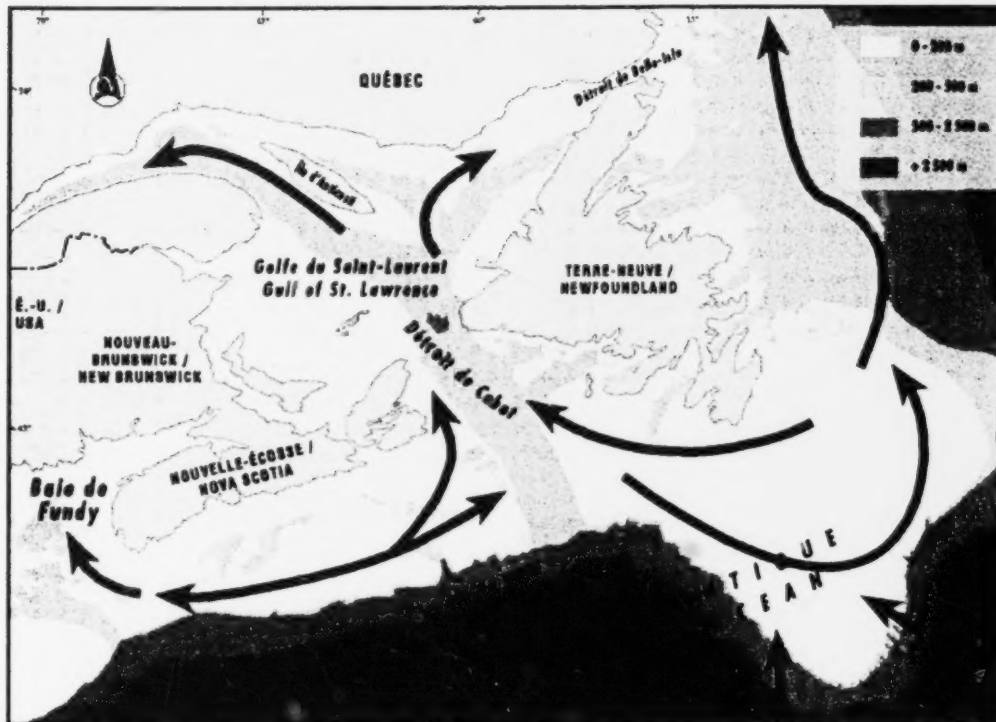
Common Name	Distribution	Food Preferences
Atlantic long-finned pilot Whale	NW Atlantic; large inshore pods from June to November; strandings in Cape Breton	Squid, cod, mackerel, groundfish
Sperm whale	Worldwide ; common on the Scotian Shelf and Slope in water from 200 to 1,500 m deep	Squid, fish
Atlantic white-sided dolphin	North Atlantic; in Gulf of St. Lawrence in summer ; common along shelf edge in waters >200m	Sand lance, schooling pelagic fish, squid
Short-beaked common dolphin	Worldwide on edge of banks and continental shelf in water from 100-1,000 m	Mackerel, herring, capelin, squid
White-beaked dolphin	North Atlantic, more common in Gulf of St. Lawrence than Scotian Shelf	Squid, cod, capelin
Blue whale	Worldwide; migrates to/from summer feeding grounds in Gulf of St. Lawrence and southern Greenland	Euphausiids
Fin whale	Worldwide; winters from ice edge south to Florida; migrates to/from summer feeding grounds in Gulf of St. Lawrence; often seen in Bay of Fundy, offshore Nova Scotia, Chedabucto Bay	Euphausiids, sand lance, mackerel, squid, herring, copepods
Humpback whale	Widely distributed over shallow banks and in shelf waters off Nova Scotia, from spring to fall; Bay of Fundy, offshore Cape Breton, Gulf of St. Lawrence	Euphausiids, sand lance, capelin
Minke whale	W Atlantic, May northward migration; concentrates in Gulf of St. Lawrence in summer	Sand lance and other small fish, krill

The endangered blue whales are the earliest migrants, appearing along the Shelf Edge in March, when they would be expected to occur in or around the Misaine SEA area. Fewer than 250 mature individuals are known in the North Atlantic, and there are strong indications of a low calving rate and low recruitment to the studied population (COSEWIC 2005).

In general, blue whales are highly nomadic, with low local resident times (Reeves et al. 1998), visiting the Gulf less regularly and for shorter period than fin whales. They range widely among their summer feeding grounds (Sears and Larsen 2002), and are found in spring, summer and fall in the Gulf of St. Lawrence (Figure 4-7), especially off eastern Nova Scotia and along the north shore of the Gulf, from the St. Lawrence River estuary



to the Strait of Belle Isle (Waring et al. 2004). In general, they begin to leave in late October and most are gone from the Gulf, and presumably the Misaine SEA area, by December (Jerry Conway, Advisor, Marine Mammals, DFO, 2005, pers. comm.). They have been documented occasionally during the winter in the Gulf, and some are known to feed on plankton concentrations along the edge of pack ice in the Cabot Strait.



Source: Sears (1999)

Figure 4-7: Movement Patterns of Blue Whales off Atlantic Canada

The highly endangered northern right whale, with a total population of only around 300 individuals, has been intensively studied in the western North Atlantic since 1980 (Waring et al. 2004). Their main summer feeding grounds are the Bay of Fundy and the southwestern Scotian Shelf; they prefer water depths of 100 m to 150 m on the continental shelf, near steep bottom slopes (Brown et al. 1995). The right whale's historical summer feeding grounds included the Gulf of St. Lawrence; two different right whales were identified in July of 2000 off Mingan Island by the Mingan Island Cetacean Study team (Jerry Conway, Advisor, Marine Mammals, DFO, 2005, pers. comm.). It is therefore possible that individuals could be found on the eastern Scotian Shelf, but in very low numbers. The likelihood of right whales occurring in the Misaine SEA area appears very low, although the potential does exist.

In summer, humpback, sei, fin, minke, pilot and blue whales are more common on the Shelf itself than are sperm and northern bottlenose whales, which prefer deeper water.



The northern bottlenose whale does not appear to frequent the edge of the Laurentian Channel; its distribution concentrates around the Gully, Haldimand and Shortland Canyons.

Migrations out of the study area to the south begin in October and November, with most migrants out of the area by January.

Small toothed whales, dolphins and porpoises may be in the study area year round. However, in general, most species frequent the Shelf and Shelf Edge during summer and early fall, moving to the southwest as winter approaches. This may coincide with seasonal distributions of favoured prey (Kenney 1994).

4.7.2 Seals

Four species of seals are known or expected to occur in the Misaine SEA area, none of which is a species of concern under *SARA*. Populations of grey, harp, and hooded seals are on the increase, all of which favour offshore waters. The population status of the harbour seal, a primarily inshore species, is less certain. The seismic class assessment provides specific information on hearing ranges and sensitivities for seals (p. 148).

4.8 Marine Turtles

Three Atlantic marine turtle species have been recorded in Nova Scotia waters: Kemp's Ridley (*Lepidochelys kempii*), loggerhead (*Caretta caretta*) and Atlantic leatherback turtles (*Dermochelys coriacea*).

The leatherback is the largest living turtle. A migratory sea turtle, it breeds in tropical or subtropical waters, and moves to temperate waters at other times of the year in search of food, mainly jellyfish. On the east coast of Canada, leatherbacks are often sighted between June and October, moving south to nest from November to April. Major areas of feeding concentrations are off southwestern Nova Scotia, near Halifax, and in Sydney Bight, with a generally northward movement in June and a southward movement in October (CWS 1999).

4.9 Sea Birds

The seabird fauna of the Scotian Shelf is characterized by a variety of pelagic species widely distributed offshore throughout the year, and by concentrations of seabirds nesting in coastal colonies from late spring through summer. The offshore seabird community is composed primarily of shearwaters and storm-petrels during the summer months, and alcids and fulmars during the winter.

Throughout the year, the greatest concentrations of pelagic species are near the edge of the continental shelf and on the shallow fishing banks (Thomson et al. 2001). Seabirds include summer and winter residents, as well as those migrating to other areas.



Seabirds are common on the offshore Scotian Shelf throughout the year. Resident summer and winter pelagic species are abundant and widely distributed, and migrant species transit the area. Inshore, concentrations of seabirds nest at coastal colonies from late spring through summer, and different populations of waterfowl are common throughout the year, some breeding, some wintering. Distributions reflect oceanographic conditions and habitat availability and appear to be driven by underwater currents and food sources (Thomson et al. 2000).

Most common in the offshore Misaine study area are northern fulmars (*Fulmarus glacialis*), greater and sooty shearwaters (*Puffinus gravis* and *P. griseus*), Leach's and Wilson's storm-petrels, (*Oceanodroma leucorhoa* and *Oceanites oceanicus*), gulls (*Larus* spp.), terns (*Sterna* spp.), alcids (*Alle*; *Uria*; *Alca*; *Fratercula*; and *Cephus* spp.), northern gannets (*Sula bassanus*) and black-legged kittiwake (*Rissa tridactyla*). Closer to shore and along the coasts are breeding colonies and winter habitat for a variety of sea ducks and other waterfowl, including common eiders (*Somateria mollissima*), double-crested and great cormorants (*Phalacrocorax auritus*, *P. carbo*), and Canada geese (*Branta canadensis*) (Breeze et al. 2002; Brown 1986; Lock et al. 1994; Tufts 1986).

A database of PIROP (Program Intégré des Recherches sur les Oiseaux Pelagiques) seabird observations off Canada's East Coast is maintained by the Canadian Wildlife Service. PIROP is the most comprehensive and long-term dataset regarding the offshore distribution of seabirds in the study area and provides an indication of seasonality and abundance of pelagic birds. Data showed that the highest concentrations of pelagic birds are found along the Shelf Edge and in areas of enhanced turbulence, upwelling, and mixing (Breeze et al. 2002).

4.9.1 Seasonal Distributions of Pelagic Birds

Pelagic seabirds use the Misaine Bank SEA area year-round; resident populations are found in summer and winter, as well as those migrating through to other areas. Abundance peaks from April to June; the highest numbers of birds are found along the edge of the Laurentian Channel, but relatively high concentrations are spread through most of the study area. Overall distributions shift to the south-west as the year progresses, with fewer birds in the study area from July to September, though still wide-spread throughout it. Offshore numbers are relatively low, or lacking altogether from October to December, but concentrations are found close inshore and along the western edge of the study area.

In winter, from January to April, high numbers of birds are found over the deeper parts of the bank, and along the edge of the Laurentian Channel. In general, the edge of the Scotian Shelf is wintering or migration habitat for dovebies (*Alle alle*), phalaropes (*Phalaropus* spp.), and, in summer, shearwaters. In winter, alcids (mainly dovebies and murre (*Uria* sp.)), fulmars and kittiwakes are the most common species; shearwaters and storm-petrels are most common in summer.



Of the main offshore species, greater shearwaters (*Puffinus gravis*) are most abundant from July to September while sooty shearwaters (*Puffinus griseus*) are most abundant between April and June. Northern fulmars are present throughout the year, but are most abundant between October and December, and least abundant between January and April.

The lowest numbers of gulls, jaegers (*Stercorarius* sp.) and skuas (*Catharacta skua*) are present during the period from April to June. At this time, gulls and kittiwakes are gathered at coastal breeding colonies foraging mainly in close proximity to the colonies. Northern gannets are most abundant during June and July. Terns generally stay within six kilometres of their colonies and are unlikely to occur within the study area.

Large numbers of Leach's storm-petrels arrive in Canadian waters in May. They remain abundant until early autumn when they migrate south following the end of the breeding season.

Wilson's storm-petrels breed in the Southern Hemisphere on Antarctica and adjacent islands. They spend the austral winter in the Northern Hemisphere. Migrating birds begin to appear in large numbers in May and remain abundant until August, when they begin to migrate south. Wilson's storm-petrel is the more abundant of the two species.

4.9.2 Foraging Patterns and Prey Species

Productive areas containing high concentrations of preferred prey species will likely be highly used by seabirds; for example, seabirds often congregate where plankton is concentrated in areas of tidal- or wind-induced upwellings and fronts where water masses meet (Breeze et al. 2002).

Breeding seasons, colony locations and movements of seabirds are largely dependent on spatial and temporal variations in the abundance of food species. Most birds breed in other areas; however, the study area provides an important feeding source for pelagic birds year-round. In NAFO Division 4VsW, seabird annual food consumption is estimated to be some 60,000 tonnes, about two-thirds of the consumption of grey seals in the same area (O'Boyle 2000).

4.9.3 Coastal Waterfowl and Seabirds

A number of Important Bird Areas (IBAs), provincially protected Wilderness Areas, and Migratory Bird Sanctuaries are located along the southern coast of Cape Breton (Table 5-1 in Section 5-1, Special Places). They contain breeding habitat for seabirds and coastal waterfowl, resting and feeding areas for migratory birds, and winter habitat for northern breeders.

Of particular note along the coast are the great cormorant breeding colonies. Most (around 70%) of North America's great cormorants are found in Nova Scotia, and the colonies adjacent to the study area together contain about 20% of the North American



breeding population. At Gabarus, the ranges of the great cormorant and the double-crested cormorant overlap, and the colony on Sugar Loaf Island, off Cape Gabarus, is one of only five rookeries in the province used by both species.

Annual Christmas bird counts provide an overview of species present along the coasts in the late fall and winter. A wide variety of other species have been recorded in smaller numbers, including the endangered harlequin duck (*Histrionicus histrionicus*). Species commonly found at Louisbourg Historic Site are:

- sea ducks, particularly long-tailed (formerly oldsquaw, *Clangula hyemalis*), common eider (*Somateria mollissima*), American black (*Anas rubripes*), red-breasted merganser (*Mergus serrator*), white-winged scoter (*Melanitta fusca*) and common goldeneye (*Bucephala clangula*);
- herring, great black-backed, and Iceland gulls;
- black guillemot (*Cepphus grille*);
- purple sandpiper (*Calidris maritime*);
- and dovebies.

On the east coast, past Scaterie Island, Glace Bay records show a different species distribution. The three gull species, the Canada goose (*Branta canadensis*, not found in the Louisbourg records), and the American black duck were present in very large numbers, with many more than on the south coast. However, no eiders, guillemot, sandpiper nor scoter were seen, many fewer mergansers, and almost no dovebies. Only the common goldeneye was seen in roughly comparable numbers in both locations.

4.10 Species at Risk

The *Species at Risk Act (SARA)* established Schedule 1 as the official list of wildlife and plant species at risk. It classifies those species as extirpated, endangered, threatened, or of special concern.

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has assigned national status to species at risk in Canada for over 25 years. Under *SARA*, COSEWIC continues to provide scientific assessments of species status, and submits them to the Minister of the Environment. The federal government, through the Governor in Council, then decides which species are added to the official list after a period of review and public notice. Recovery planning and implementation for listed *SARA* species, (and others assessed as at risk by COSEWIC), will be developed and implemented through the collaborative National Recovery Program (RENEW, 2004).

When Parliament passed *SARA* in 2002, Schedule 1 included 233 species, which COSEWIC had already reassessed using new assessment criteria and current data. Schedule 2 included endangered or threatened species, and Schedule 3 species of special



concern, that COSEWIC had designated at risk over the years, but had not yet reassessed as of the end of 2001. These species are now undergoing reassessment using revised criteria before they can be considered for addition to Schedule 1. Once done, these reassessments are sent to the Minister of Environment to undergo the listing process (Environment Canada, 2003).

Table 4-5 summarizes those marine species which may occur in the study area and which have COSEWIC/SARA designations in categories other than Not At Risk.



Table 4-5: Species with COSEWIC/SARA Designations in the Study Area

Common name	Latin name	SARA Schedule #	Range/Population	Risk category COSEWIC/SARA Schedule 1	Year Assessed
FISH					
Atlantic salmon*	<i>Salmo salar</i>	1	Atlantic Ocean; Inner Bay of Fundy	Endangered (both)	2001
Northern wolffish	<i>Anarhichas denticulatus</i>	1	Atlantic Ocean	Threatened (both)	2001
Spotted wolffish	<i>Anarhichas minor</i>	1	Atlantic Ocean	Threatened (both)	2001
Atlantic wolffish	<i>Anarhichas lupus</i>	1	North Atlantic Ocean	Special Concern (both)	2000
Atlantic cod	<i>Gadus morhua</i>	3, under consideration for 1	Maritimes population	Special Concern (COSEWIC)	2003
Cusk	<i>Brosme brosme</i>	under consideration for 1	Atlantic Ocean	Threatened (COSEWIC)	2003
Porbeagle shark	<i>Lamna nasus</i>	under consideration for 1	Atlantic Ocean	Endangered (COSEWIC)	2004
MAMMALS					
Blue whale*	<i>Balaenoptera musculus</i>	1	Atlantic and Pacific Oceans	Endangered (both)	2002
Fin whale*	<i>Balaenoptera physalus</i>	3	Atlantic and Pacific Oceans	Special Concern (COSEWIC)	1987
Harbour porpoise	<i>Phocoena phocoena</i>	2 (Threatened)	Northwest Atlantic Ocean	Special Concern (COSEWIC)	2003
Northern bottlenose whale	<i>Hyperoodon ampullatus</i>	3; under consideration for 1	Scotian Shelf population	Endangered (COSEWIC); Special Concern (SARA)	2002
North Atlantic right whale *	<i>Eubalaena glacialis</i>	1	Atlantic and Pacific Oceans	Endangered (both)	2003
Sowerby's beaked whale	<i>Mesoplodon bidens</i>	3	Atlantic Ocean	Special Concern (COSEWIC)	1989
TURTLES					
Leatherback sea turtle*	<i>Dermochelys coriacea</i>	1	Atlantic and Pacific Oceans	Endangered (both)	2001
BIRDS					
Barrows goldeneye	<i>Bucephala silandica</i>	1	Eastern population	Special Concern (both)	2000
Harlequin duck	<i>Histrionicus histrionicus</i>	1	Eastern population	Special Concern (both)	2001
Ivory gull	<i>Pagophila eburnea</i>	1	Northern population	Special Concern (both)	2001
Roseate tern*	<i>Sterna dougallis</i>	1	Atlantic, Indian and Pacific Oceans	Endangered (both)	1999

Source: COSEWIC 2004; SARA 2005; US FWS 2005. * = also listed as endangered by the United States



5 HUMAN ACTIVITY

5.1 Special Areas

Special areas of concern to this SEA would include features such as fishing closures, whale conservation areas, areas of corals, other marine protected areas or munitions dumps. No specific management or closed areas exist within the Misaine SEA area. However, deep sea corals may be found in the area and a potential management plan for their protection is described. Sensitive coastal areas along the eastern shore of Cape Breton are also described because of their proximity to the SEA area. It should also be noted that MARLANT (Department of National Defense) conducts approximately 105 exercises in the western part of the SEA area annually.

5.1.1 Coral Areas

Cold water corals are the focus of increasing conservation attention as some species are particularly sensitive to human activities, and they appear to be important biodiversity hotspots (Freiwald et al. 2004). The Misaine SEA area is included in the draft Coral Conservation Plan (Maritimes Region, 2005 – 2010). The plan is a component of the Eastern Scotian Shelf Integrated Management Plan, but includes all waters off the Atlantic coasts of Nova Scotia and New Brunswick, an area larger than the ESSIM planning area. The plan focuses on those coral species found at depths below 150 m, in areas with particular environmental characteristics; it was released for comment in February 2005, and a revision is expected in June (DFO 2005b).

The plan sets out a number of objectives for conservation, management and research; of these, the following are particularly relevant to the Misaine SEA:

- conserve the health and integrity of coral communities, including minimizing the impacts from human activities;
- implement a flexible and adaptive approach to management and decision-making;
- balance coral conservation with human use;
- support and promote scientific research on corals, including understanding and assessing the impacts of human activities on corals, distribution of corals, and evaluating current and proposed management measures to conserve corals; and
- foster information-sharing and collaboration on coral research.

Deep water coral reefs may provide habitat, feeding grounds, recruitment and nursery functions for a range of deep-water organisms, including commercial species of crustaceans and fish. However, the full ecological importance of corals is still unknown. Areas where coral ecosystems occur share several common characteristics:



- the seasonal storm wave base does not disturb the seabed;
- strong currents prevent sediment deposition and create hard substrate;
- water flows funnel through narrow passages like submerged canyons, straits, channels, or fjord troughs, and
- nearby nutrient-rich waters trigger high phyto and zooplankton levels, providing plentiful food (Freiwald et al. 2004).

Two major coral groups, totaling some 25 to 30 species are known or thought to occur in the Atlantic waters off Nova Scotia. Hard (or stony) corals, *Scleractinia*, occur both as colonial species that build large reefs, and as solitary forms. Most stony coral species off Nova Scotia are solitary, non-reef building species such as the cup coral, *Flabellum alabastrum*. One important reef-building species, *Lophelia pertusa*, has been identified (DFO 2005c). It is the most common habitat-forming, reef-building cold water coral, growing in bush-like colonies that merge into very large reef structures; it has been recorded at depths from 39 m to 3,383 metres.

A large *Lophelia pertusa* reef was confirmed by ROV surveys in the Stone Fence area on the edge of Banquereau Bank (see Figure 5-1), at the mouth of the Laurentian Channel, in 2003 (Freiwald et al. 2004). It is the only known location with living *Lophelia p.* in Atlantic Canadian waters. The reef and the area surrounding it are heavily damaged from fishing gear and recovery may take decades. The Lophelia Coral Conservation Area was established in 2004 to protect a small area, centred on the reef with a one nautical mile buffer zone around it, containing both living and damaged areas of the reef complex. It is closed to all fishing activities, which primarily affects otter trawling for redfish and longlining for halibut. The area does not include all sites in the Stone Fence and Laurentian Channel with corals (DFO 2005c).

The large, diverse group of octocorals (*Octocorallia*) is distantly related to the stony corals and includes soft corals, sea fans, sea whips and sea pens. They have been recorded at depths as shallow as eight meters, although most are found in deeper waters on the Scotian Slope, in the channels between the fishing banks, or in canyons. The soft corals anchor to hard substrate and form large, long-living colonies; many, like the gorgonian octocorals, grow in a tree-like shape that can extend several metres above the sea floor. 'Gardens' or 'forests' comprised of these trees are found in a number of sites off Nova Scotia, often in association with *Lophelia p.*, including the Stone Fence (DFO 2005c).

Cup corals (*Flabellum* spp.) have been collected and observed on many parts of the Scotian Slope. They are also found on soft sediments in basins of the Scotian Shelf and Gulf of Maine, often with sea pens (*Pennatulids*) and small gorgonian corals that are able to anchor in soft muds (Freiwald et al. 2004).



In and near the study area, the holes of Misaine Bank and the edge of the Laurentian Channel (particularly along St. Ann's Bank and Artimon Bank) have been identified as areas of deep sea coral distribution based on fishermen's local ecological knowledge (Gass 2004). Two trawl records of *Acanthogorgia armata* are from the edge of the Misaine goles on the eastern Scotian Shelf, found at a depth of 164 m; others have been found at up to 1400 m. These Misaine records represent slightly shallower than normal occurrences (Gass 2004).

However, the areas near Misaine Bank have not yet been visually surveyed by scientists. They have been listed among the priority research areas in the Draft Coral Conservation Plan (Freiwald et al. 2004).

5.1.2 Sensitive Coastal Areas

Table 5-1 reviews special places along the coast of southern Cape Breton, including provincial and national parks, Important Bird Areas (IBA), federal Migratory Bird Sanctuaries, and provincially designated Wilderness Protected Areas. Figure 5-1 shows the location of sensitive coastal features, including the Fortress of Louisbourg National Historic Site.

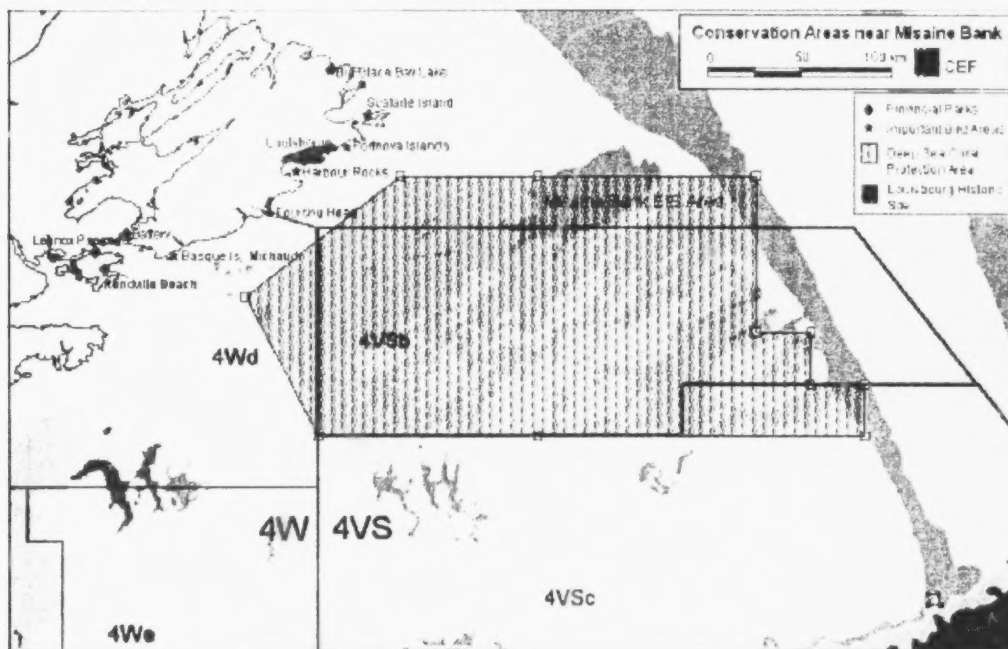


Figure 5-1: Location of Sensitive Coastal Features and the Stone Fence Coral Protection Area

In and near the study area, the holes of Misaine Bank and the edge of the Laurentian Channel (particularly along St. Ann's Bank and Artimon Bank) have been identified as areas of deep sea coral distribution based on fishermen's local ecological knowledge (Gass 2004). Two trawl records of *Acanthogorgia armata* are from the edge of the Misaine goes on the eastern Scotian Shelf, found at a depth of 164 m; others have been found at up to 1400 m. These Misaine records represent slightly shallower than normal occurrences (Gass 2004).

However, the areas near Misaine Bank have not yet been visually surveyed by scientists. They have been listed among the priority research areas in the Draft Coral Conservation Plan (Freiwald et al. 2004).

5.1.2 Sensitive Coastal Areas

Table 5-1 reviews special places along the coast of southern Cape Breton, including provincial and national parks, Important Bird Areas (IBA), federal Migratory Bird Sanctuaries, and provincially designated Wilderness Protected Areas. Figure 5-1 shows the location of sensitive coastal features, including the Fortress of Louisburg National Historic Site.

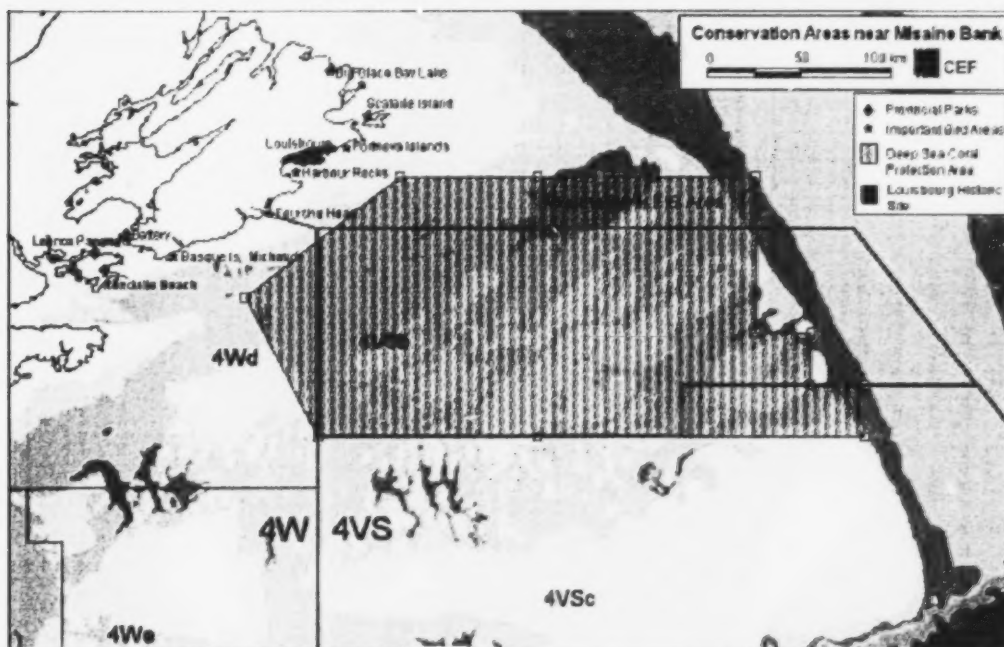


Figure 5-1: Location of Sensitive Coastal Features and the Stone Fence Coral Protection Area

Table 5-1: Designated Special Areas along South Coast of Cape Breton Island

Location	Designation	Species of Interest
Basque Islands and Michaud Point	IBA NS045, Point Michaud Provincial Park.	Great Cormorant breeding colony on Basque Island with about 4% of the N. Amer. population. Common Eider breeding colony; staging area for Canada geese and other waterfowl; park has 3 km sand beach, dunes.
Fourchu Head Rocks	IBA NS047	Great Cormorant breeding colony with at least 2% of the N. Amer. population.
Gabarus	Harbour Rock IBA NS049; Gabarus Wilderness Area, including Green Island	Great and Double-crested Cormorant breeding areas; concentrations of immature eiders in fall and winter. Green Island most southerly nesting colony of Black-Legged Kittiwakes; migratory shorebird staging area; Great Cormorant breeding Colony with at least 2% of N. Amer. population.
Glace Bay	Big Glace Bay Lake IBA NS007, Migratory Bird Sanctuary; Northern Head and South Head, Glace Bay IBA NS053; near Marconi National Historic Site of Canada at Table Head	Lake is major Canada Geese migratory staging area, smaller numbers of other migrants and waterfowl; Heads have Great Cormorant breeding colonies with about 7% of estimated North American population. Some Harlequin ducks in winter in the Bay.
Isle Madame	Pondville Beach Provincial Park; Lennox Passage Provincial Park	PB: 1 km sand beach, dunes, salt marsh, lagoon; LP: beach
Louisbourg area	Harbour Rocks IBA NS049; Portnova Islands/Chateau Rock IBA NS006; Fortress of Louisbourg National Historic Site of Canada	Great Cormorant breeding colonies with at least 5% of the N. Amer. population; some Harlequin ducks in winter; major national historic site.
Scatarie Island/Main-a-Dieu	IBA NS052, Scatarie Island Wilderness Area	Leach's Storm-Petrel breeding area; large numbers of migrating Whimbrels feed inland
St. Peters	Battery Provincial Park; St. Peters Canal National Historic Site of Canada; St. Peters National Historic Site of Canada	Provincial park has beach and historic sites.

5.2 Ship Traffic

Figure 5-2 shows the marine vessel traffic across the East Coast of Canada, measured in trips per year in each grid square (CEF 2004). Data sources were the ECAREG/NORDREG database, reporting points from ships traveling through Atlantic Canada and stopping at Canadian ports; and Lloyds of London ship movement data, which encompasses other ships moving through waters off the Canadian coast, primarily between the USA and Europe. Darker shades correspond to greater concentrations. These data indicate the Misaine SEA area has a moderate intensity of ship traffic compared to other parts of the Scotian Shelf.

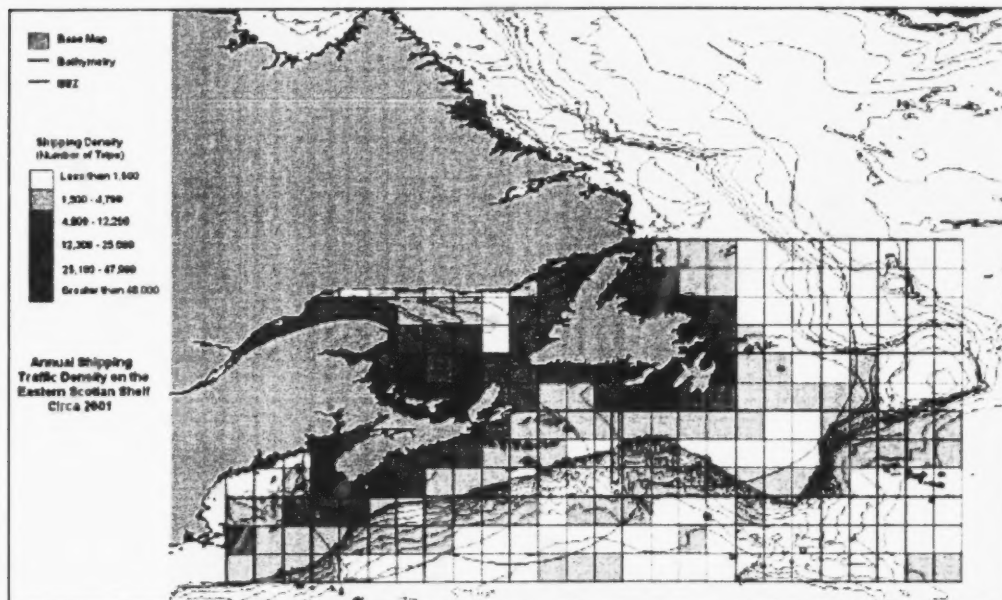


Figure 5-2: Estimated Merchant, Cruise and Fishing Vessel Traffic Density circa 2001

5.3 Fishing Activity

5.3.1 Abundance and Management

Fisheries are managed by a complex set of regulations within management areas, which vary by species or species group. Most finfish and shellfish important in the Misaine SEA area are managed within the divisions and unit areas illustrated in Figure 5-3. Most of the Misaine SEA area falls within Unit Area 4VSb and Crab Fishing Area 23.



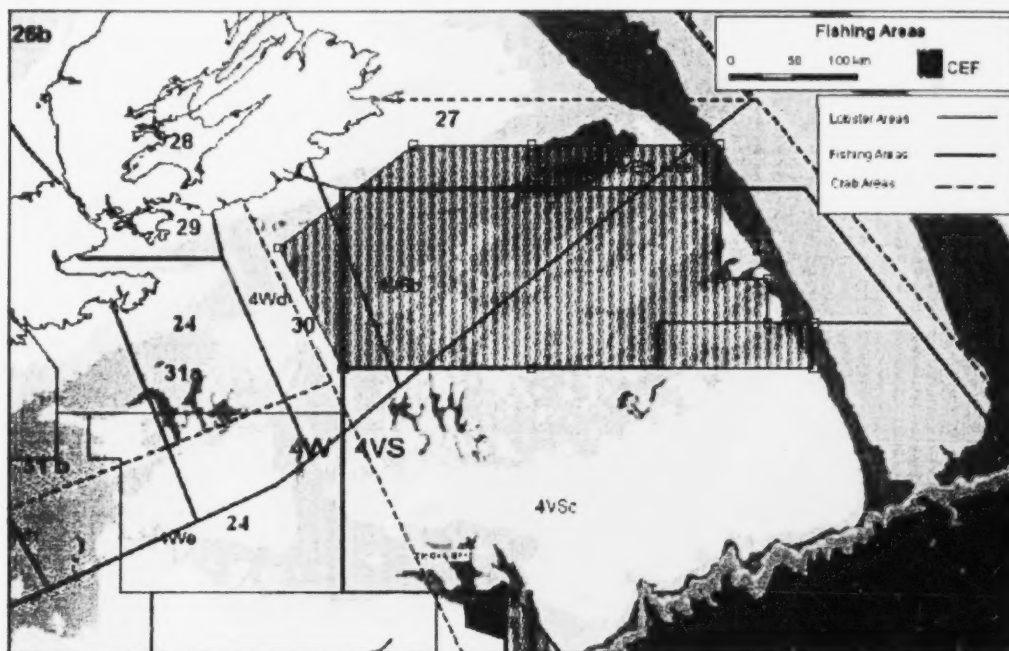


Figure 5-3: Fisheries Management Areas for Finfish, Snow Crab and Lobster

5.3.1.1 Shrimp and Crab

The northern shrimp stocks on the Misaine Bank (SFA 14) are at high levels, but the fishery is not necessarily located in areas of highest biomass because of the natural segregation of desired age classes. The overall indicators for this stock are good; with spawning biomass, total biomass, and recruitment all being high (DFO 2004a).

The snow crab TAC was reduced in 2004 from 2003 but the immediate prospects for recruitment remain poor. Spawning and total biomass are both declining. Lowered harvesting levels have been recommended again for 2005 (DFO 2005a).

Jonah crabs are taken as bycatch within the Misaine SEA area, but their stock status is uncertain (DFO 2000a).

5.3.1.2 Groundfish

The Atlantic cod fishery has been in moratorium since 1993. On Misaine Bank (4VsW), Atlantic cod are a bycatch only species. The spawning biomass remains the lowest on record, with no indications that the recovery of the fishery is occurring or imminent (DFO 2003b).

American plaice and yellowtail flounder (4VW) are managed as one stock complex. These flatfish stocks are at low levels within the Misaine SEA area. Landings for 2001 were one-quarter of the TAC. Spawning biomass, recruitment and distribution of the

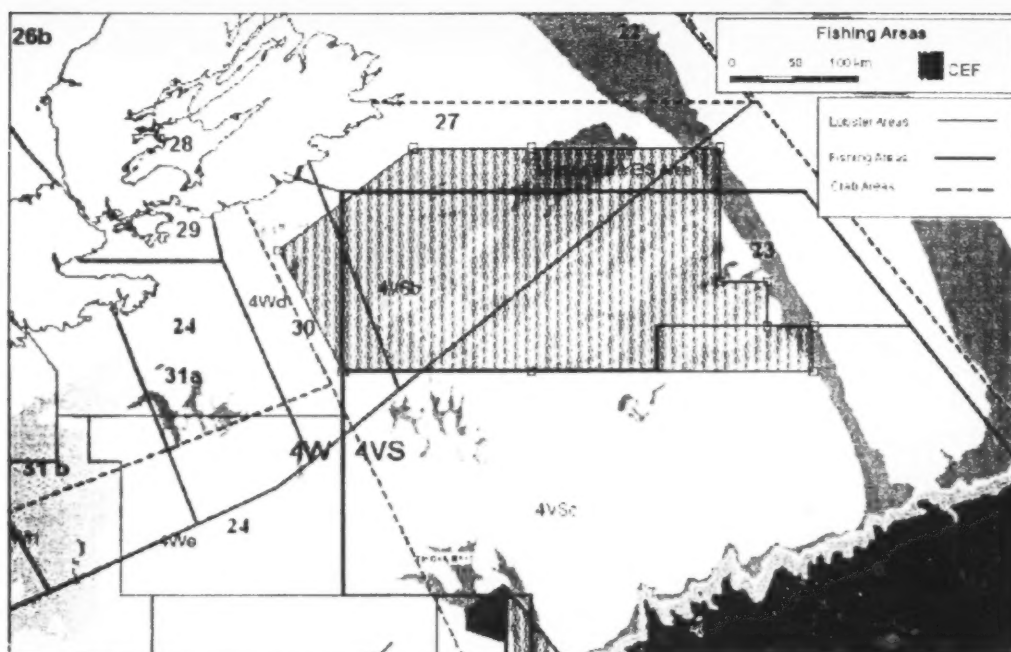


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stock are also at low levels, although indications for recruitment are improving (DFO 2002b).

The stock structure of Monkfish (4VWX) is presently not well understood. Monkfish have been fished as bycatch since 1995. Recruitment is improving, but spawning biomass is below average and total biomass is low (DFO 2002d).

Atlantic halibut (4VWX3NOP) is one of the most widely distributed fish on the Scotian Shelf. Overall indications for this stock are good. Although the spawning biomass is not known, recruitment and total biomass are improving steadily (DFO 2001a).

An evaluation of pollock stocks (4VWX) has shown that the stock structure is divided into two parts: a fast growing western component, and a slower growing eastern component that includes the study area. Overall the indicator for the eastern stock is low, however, total biomass and recruitment are increasing (DFO 2004c).

Only half of the TAC for redfish was taken in 2001. Nonetheless, overall stock indications are stable (DFO 2002c).

The stock structure of witch flounder is not known but it is managed as a single stock on the Scotian Shelf (4VWX). Landings from all areas have declined in recent years, but overall indicators are intermediate. The spawning biomass is at intermediate levels, but recruitment is good (DFO 2002c).

Winter skate abundance is near historic lows, with biomass, spawning biomass, and recruitment all low. Low fecundity, late maturity, and slow growth makes this species susceptible to overexploitation (DFO 2002a).

5.3.1.3 Pelagic and Estuarial

Colder than normal bottom temperatures led to what appears to be a sustained capelin population on the Scotian Shelf. There is not a directed fishery for capelin on the Shelf, but experimental licences have been granted in the past (1995 - 1996). Overall indications are that the stock is increasing (DFO 1998b).

The herring stocks (4VWX) consist of a number of different spawning populations. Overall indications are that the stock is increasing (DFO 2004d).

5.3.1.4 Summary of Stock Status

Table 5-2 provides an overview of the status of the commercially important species in the study area from the latest DFO stock status reports available.



Table 5-2: Stock Status of Species on Eastern Scotian Shelf

Species	Landings (‘000t) (year)	TAC (‘000t) (year)	Overall Indicator	Spawning Biomass	Recruitment	Distribution
Capelin (4VW)	.01 (1996)	Bycatch	Increasing	Uncertain, Likely increasing	Increasing	Increasing
Cod (4VsW)	.08 (2002)	Bycatch	Collapsed	Lowest Recorded	< Average	< Average
Cusk (4VWX)	1.14 (2001)	Bycatch	Low	Low	No sign	No Major Change
Flatfish* (4VW)	.70 (2001)	3.0 (2001)	Very Low	Very Low	Low & Improving	Low
Halibut (4VWX3NOPs)	.5 (2001)	1.15 (2001)	Improving	Unknown	Improving	Widely distributed
Herring (Banks)	1.0 (2003)	12.0 (2003)	Declining	Decreasing Slightly	Steady	Widely distributed
Monkfish (4VWX5Zc)	1.0 (2001)	Bycatch (2001)	< Average	< Average	Improving	Average
Pollock (4VWX5Zc)	6.54 (2004)	10.0 (2004)	West, average East, low	Uncertain, Likely Increasing	Increasing	Widely Distributed
Porbeagle Shark	.9 (2000)	.85 (2000)	Seriously Depleted	Low	Low	Widely distributed
Redfish (4Wdehkl1X)	4.7 (2001)	9.00 (2001)	Apparently stable	Uncertain/ Apparently Stable	Moderate	Widely Distributed
Winter Skate	.15 (2002)	.2 (2002)	Low	Low	Low	Near Historical Low
Witch Flounder (4VWX)	.61 (2001)	No Specific Quota	Intermediate	Intermediate	Strong	Average
Wolfish (4VWX5YZc)	.112 (2001)	Bycatch	Low	Very Low	> Average	< Average
Northern Shrimp (SFA 13-15)	3.5 (2004)	3.5 (2004)	Good	High	High	Widely distributed
Snow Crab (Eastern NS)	10.6 (2003)	10.6 (2003)	Decreasing	Decreasing	Low	Widely Distributed

Source: DFO Stock Status Reports (DFO 2005a; 2004c; 2004d; 2002a; 2002b; 2002c; 2002d; 2001a; 1998c;

5.3.2 Pre- and Post-Moratorium Fishing Activity

Table 5-3 shows the average annual pre-Moratorium and post-Moratorium landings for Fisheries Management Divisions 4Vn, 4Vs, and 4W. Major commercial species caught on or near Misaine Bank include snow crab, shrimp, halibut, Greenland halibut, shark, and in some years, Atlantic herring.

The closure of the cod fishery and restrictions on fishing many other groundfish in 1993 led to a drastic reduction of groundfish landings in all three divisions; however, the overall catch reduction is proportionally smaller in 4W. Declines in herring and mackerel landings in 4Vn and 4W also occurred during this period. Total landings for large pelagic species, such as tuna, remained approximately the same pre and post moratorium. Catches of large pelagics were generally restricted to offshore areas of 4Vs, outside of the SEA area, and 4W. Landings of shark, particularly porbeagle and blue, were highest in 4W. Large numbers of skate were landed in 4Vs after the moratorium, accounting for the large increase in landings for this division. Other finfish includes estuarial species such as alewife and shad. Alewife was particularly abundant in inshore areas of Divisions 4Vn and 4W, but not 4Vs.

Shellfish landings increased considerably in all divisions post moratorium. The snow crab catch increased significantly in 4Vs and 4W after the codfish closure. Lobster catches in 4VW and 4Vn decreased but the value of this fishery increased. The lobster fishery is restricted to coastal waters on the eastern Scotian Shelf, and thus no fishery for lobster occurs in 4Vs. Other invertebrate species including squid and sea urchins are caught primarily in 4W. Squid is generally restricted to offshore areas.

Table 5-3: Average Annual Pre-Moratorium and Post-Moratorium Landings for Fisheries Management Divisions 4Vn, 4Vs, and 4W

Species	PRE-MORATORIUM (1988-1993)						POST-MORATORIUM (1977-2001)					
	Average annual landing (thousands mt)			Average landed value/year (millions \$)			Average annual landing (thousands mt)			Average landed value/year (millions \$)		
	4Vn	4Vs	4W	4Vn	4Vs	4W	4Vn	4Vs	4W	4Vn	4Vs	4W
Major Groundfish	28.6	37.1	30.4	12.7	19.4	19.2	2.68	3.41	13.3	2.54	3.09	11.6
Lobster	3.02	0	0.96	18.7	0	6.99	1.41	0	0.77	16.5	0	10.0
Snow Crab	0.72	0.03	0.50	1.63	0.07	1.20	1.08	1.79	2.61	4.60	7.99	11.6
Herring	3.96	0.01	12.2	0.51	0	1.61	2.16	0	10.2	0.36	0	1.49
Mackerel	1.85	0.01	1.56	0.57	0	0.54	0.60	0.37	0.27	0.27	0.66	0.14
Large Pelagics	0	0.11	0.50	0.02	0.70	3.47	0	0.10	0.57	0.01	0.74	5.27
Sharks and Skates	0.01	0.03	0.37	0.01	0.02	0.26	0.02	0.58	0.51	0.03	0.36	0.82
Other Finfish	0.11	0	0.11	0.06	0	0.09	0.16	0	0.09	0.09	0.03	0.25
Shellfish	0.16	3.54	3.50	0.21	2.92	3.79	0.66	19.6	4.54	1.06	19.8	7.74
Other Inverts	0	0	0.35	0	0	0.16	0.07	0	1.07	0.17	0	1.64
Other	0.01	0.12	0.05	0	0.05	0.02	0	0	0.43	0	0	0.43
Total	38.5	41.0	50.5	34.5	23.2	37.4	8.85	25.9	28.7	25.6	32.6	42.5

Source: DFO Catch and Effort Statistics

Figure 5-4 is a comparison of pre and post moratorium annual average landed values for major groundfish and shellfish in NAFO fisheries divisions 4Vn, 4Vs, and 4W. Lobster is excluded from this analysis because there is no directed fishery of this species within the SEA area (DFO 2004b). In all three divisions, average annual landed values of groundfish decreased significantly after the cod moratorium and other groundfish restrictions were imposed in 1993, although the commercial groundfishery maintained a proportionally higher level of total fishery value in division 4W.



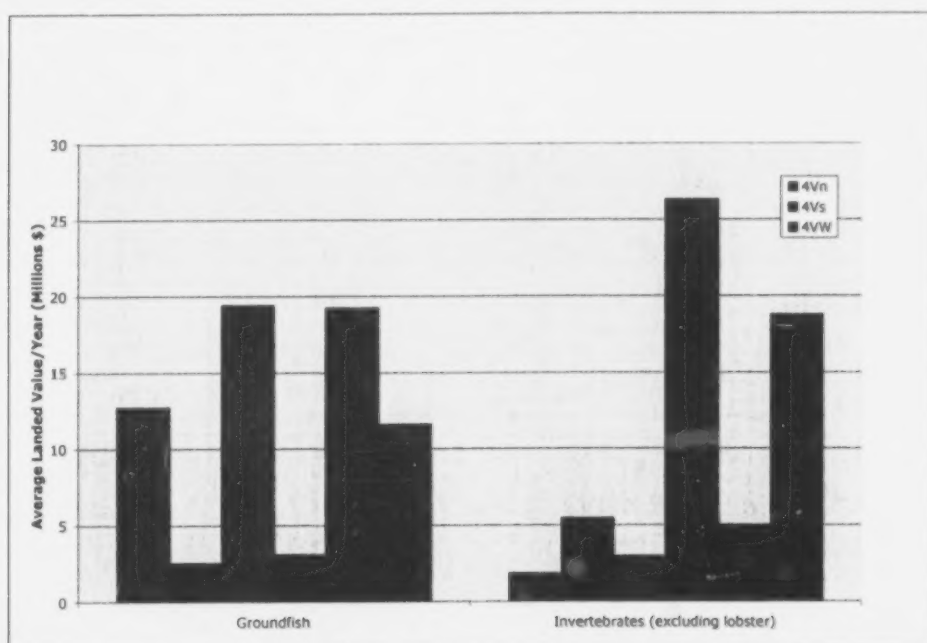


Figure 5-4: Average Annual Pre-Moratorium (1988-1993) and Post-Moratorium (1997-2001) Landed Value for Fisheries Management Divisions 4Vn, 4Vs, and 4W

Following the moratorium, the annual commercial shellfish harvest/quota increased, helping to offset the closure of the groundfishery. From 1998 to 2001, the annual landed value of shellfish in divisions 4Vs and 4W exceeded the value of the commercial groundfishery in the years prior to the moratorium. Major invertebrates fished in 4W and 4Vn prior to 1993 included scallop, stimpson surf clam, shrimp, and snow crab. Snow crab and shrimp were dominant commercial species after the moratorium. By 2001, total snow crab landings exceeded the total of all other shellfish caught (excluding lobster).

In Division 4Vs, stimpson surf clam and shrimp were the dominant shellfish caught prior to the moratorium; however, surf clam and scallop are not fished commercially in the SEA area. Shrimp are fished within the Louisbourg Hole and in deeper holes surrounding the Misaine bank (Breeze and Maris Consulting 2004). Annual snow crab landings in 4Vs increased considerably post moratorium and the value of this fishery surpassed that of all other shellfish in 2000 and 2001.

Table 5-4 provides landings from 2001 to 2003 for Unit Area 4VSb, which conforms closely to the SEA area.

Table 5-4: Landings (thousands of metric tonnes) for Unit Area 4VSb by Major Species or Species Group, 2001 to 2003

Species or Group	2001	2002	2003
American plaice	11.16	42.94	10.90
Redfish	216.53	138.84	98.95
Atlantic halibut	0.00	0.86	0.08
Skates	9.91	0.00	0.00
Other groundfish	34.65	3.73	1.75
Sharks	0.00	0.21	0.00
Large pelagics	0.25	0.54	0.00
Lobster	0.36	0.00	0.00
Snow crab	1,660.17	1477.28	1,383.22
Shrimp	133.21	8.62	10.82
Other shellfish	1.53	7.31	1.76
Total	2,067.76	1680.33	1,507.48

Source: DFO Catch and Effort Database

Maps of catch locations for the same time period are provided in the following sections for the major fisheries within this area.

5.3.3 Snow Crab and Shrimp

The SEA area is contained within Crab Fishery Area (CFA) 23; an extended season ran from June 1 to October 18 in 2004 (DFO 2005a). Snow crab was the major commercial species caught in 4VSb from 2001 to 2003 (Figure 5-5). Annual catches occurred throughout the SEA area, but were generally concentrated in deeper holes and trenches on the Misaine Bank, particularly on the western portion. Major catches also occurred in areas northwest of Misaine Bank, and along the western edge of the Laurentian Channel. A significant reduction in the snow crab catch occurred in 2003; with most crab caught off the Misaine Bank, primarily northwest and to the south and east towards Banquereau Bank. Further reductions in the crab fishery occurred in 2004 and are recommended for 2005.



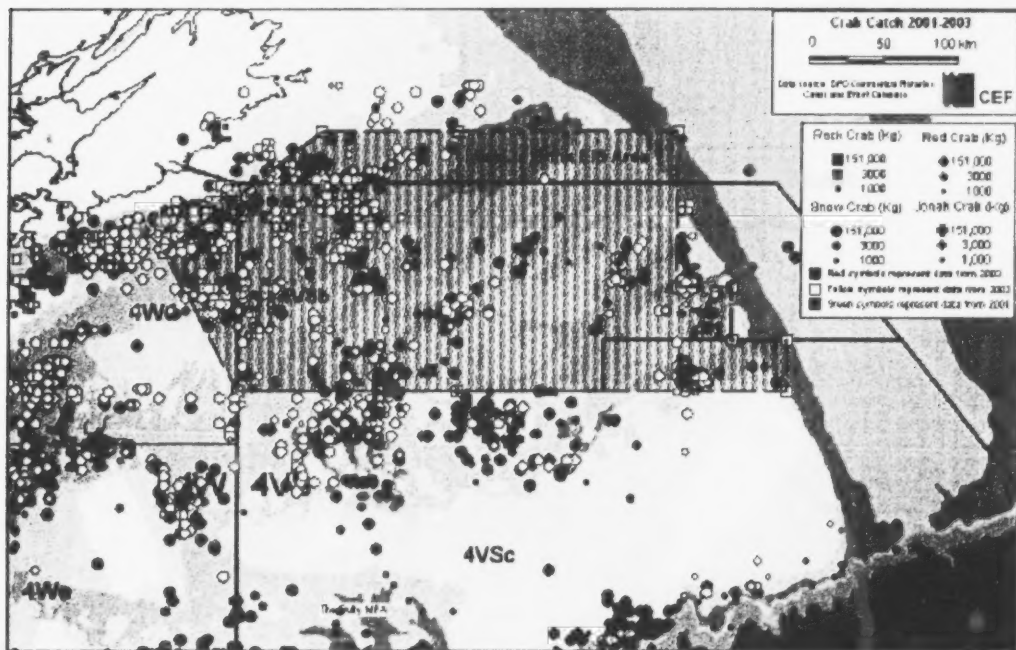


Figure 5-5: Location of Snow Crab Catches, 2001-2003

On the Eastern Scotian Shelf, the SEA area is located in Shrimp Fishery Areas 13, 14, and 15 (DFO 2004a). Between 2001 and 2003, northern shrimp fishing was concentrated in the Louisbourg Hole and in deeper holes south of Misaine Bank, outside of the SEA area (Figure 5-6). Large amounts of shrimp were also fished in 2001 and 2002 northwest of the SEA area (north of Canso bank in 4Wd). Most shrimp are caught in May and June, although recent trends have seen an increase in the amount taken between August and April, a voluntary measure to avoid soft-shelled shrimp (DFO 2004a).

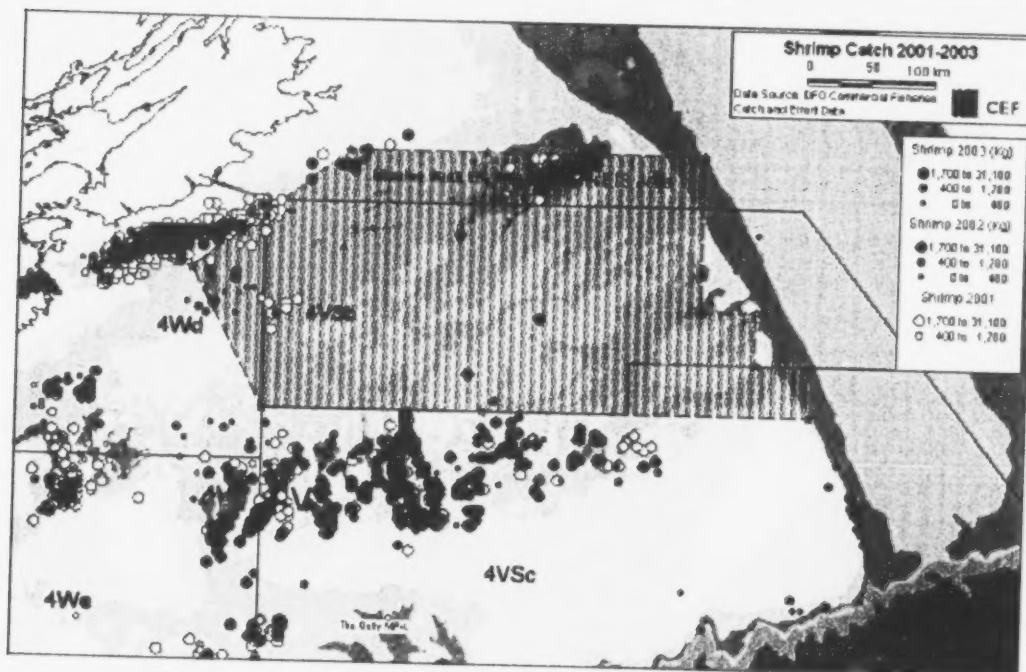


Figure 5-6: Location of Northern Shrimp Catches, 2001-2003

5.3.4 Groundfish

Figure 5-7 indicates a minor redfish catch occurred within the SEA area between 2001 and 2003 in deeper waters off Misaine Bank to the east and west. The majority of redfish were caught outside the SEA area along the Laurentian channel to the outer shelf.

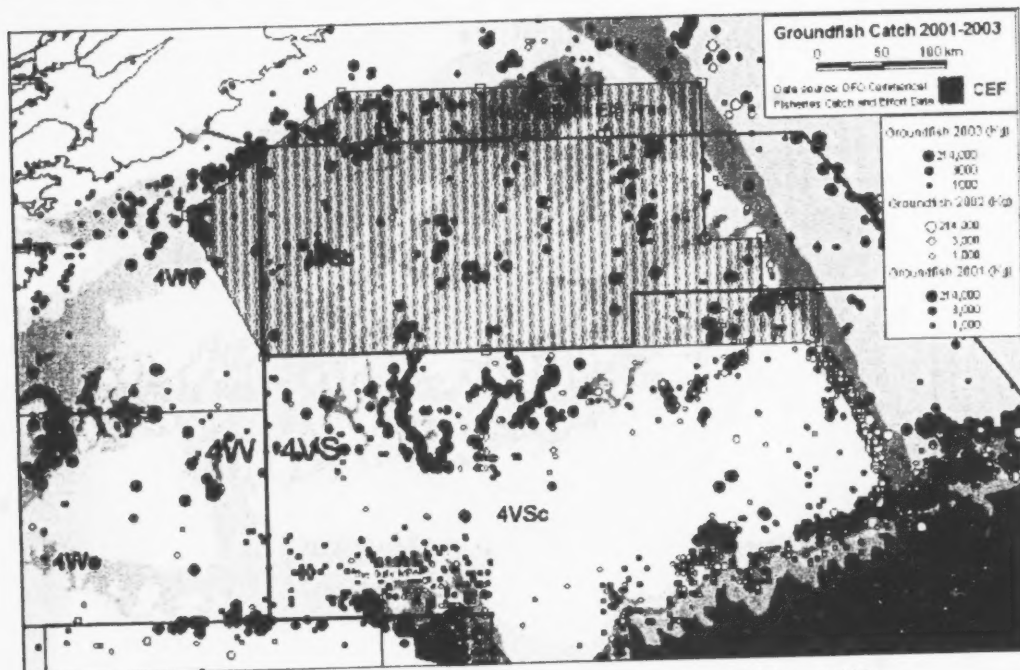


Figure 5-8: Location of Groundfish Catches, 2001 to 2003

DFO Fisheries catch and effort statistics indicated that there was no significant commercial fishery for halibut within the SEA area between 2001 and 2003. Halibut were fished primarily on the outer shelf near the Laurentian Channel and along the southwestern edge of Banquereau Bank.

5.3.5 Emerging and Experimental Fisheries

Hagfish has been taken for some time by a small inshore fishery with around nine licences in 4VSW, predating the emerging fisheries policy. Annual landings have been as much as 1000 tonnes, with skins for leather and meat primarily marketed to Korea. An experimental offshore hagfish licence has been recently issued and, as of early 2005, the licence holder is planning to survey an area that might overlap slightly with the Misaine SEA area along the eastern and possibly the southern limits. A licence holder is required to make all possible efforts to minimize or avoid any gear conflicts, and they are provided with contact information by DFO with respect to any potential offshore petroleum related activities, such as seismic surveys (Peter Hurley, DFO Science, pers. comm., 2005).

Two offshore exploration licences have been issued for sea cucumber, one for 4W, the other for 4Vs; fishing can occur anywhere in the areas as long as it is at least 80 km from shore. The 4W licence has taken 400 tonnes in the past 18 months; a work plan for the 4Vs licence is in progress. Three inshore (80 kms and less) licences take up to 4000 tonnes annually.

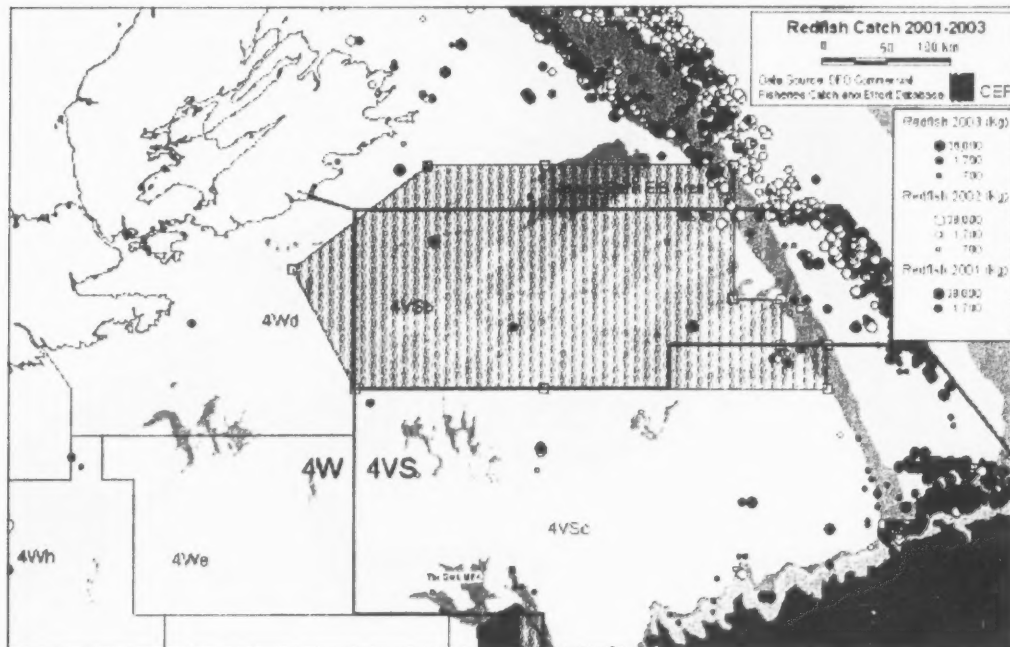


Figure 5-7: Location of Redfish Catches, 2001 to 2003

Other groundfish caught between 2001 and 2003 included cod, American plaice, haddock, and turbot; however, this was not a significant part of the commercial fishery in the SEA area. Most groundfish were caught in 2003, with much fewer numbers landed in the previous two years. Small catches occurred in deeper areas on and south of the Misaine Bank, the Louisbourg Hole, the western edge of the Laurentian Channel, and nearshore regions northwest of 4VSe (Figure 5-8).



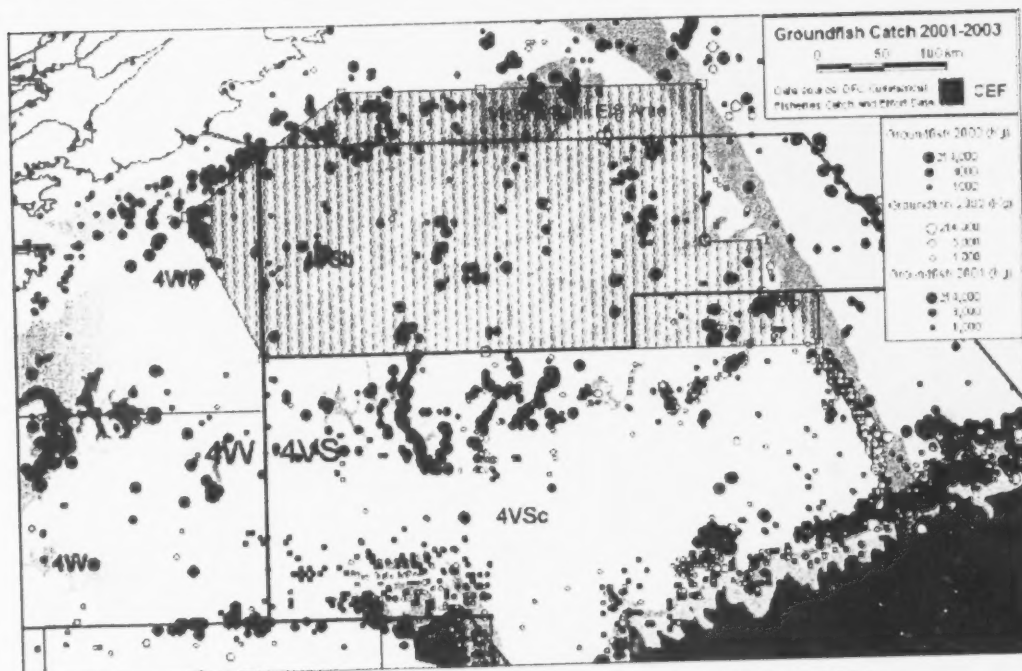


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Sea cucumber is fished at depths from 9 to 90 m; depths are limited by gear, not species occurrence. The maximum depth at which they can be found is unknown. The species is eaten in Asia and research is proceeding on potential pharmaceutical uses to combat heart disease and arthritis. Should a saleable extract be developed, the fishery is likely to grow dramatically. The potentially likely issues regarding oil and gas activities relate to the establishment of exclusion zones, and potential interactions between gear and pipelines (Mark Lundy, DFO Molluscan Fisheries, pers. comm., 2005).

6 ASSESSMENT METHODS AND CONSULTATION

6.1 Overview

The methodology employed will emphasize the environmental components of greatest concern to potentially affected parties (i.e. resource users), a method widely accepted and popularized by Beanlands and Duinker (1983).

The generic screening reports describing the environmental impacts of seismic exploration and exploratory drilling on the Scotian Shelf (Davis et al. 1998; Thomson et al. 2000) provide the primary basis of this assessment, focusing on Valued Ecosystem Components (VECs) relevant to the study area. VECs may represent "key" or "indicator" species, mixed species groups, communities, and/or ecosystems. They may also reflect issues that are of social, cultural, or economical significance (e.g., commercial fisheries).

The methodology will include an evaluation of the potential cumulative effects with regard to the identified VECs. The omission of a particular issue as a VEC does not relate to its perceived importance in general, but rather to its connection to exploration activities through identifiable pathways.

6.1.1 Regulatory Context

Federal Acts that may apply include, but are not limited to:

- *Fisheries Act*;
- *Oceans Act*;
- *Navigable Waters Protection Act*;
- *Canadian Environmental Protection Act*;
- *Migratory Birds Convention Act*;
- *Canada Wildlife Act*, and
- *Species at Risk Act*.

Numerous federal guidelines will also apply to potential petroleum exploration activities.



The *Nova Scotia Environment Act* does not apply to offshore oil and gas exploration projects.

6.1.2 Information on Exploration Activities and Impacts

Information on the potential impacts associated with oil and gas exploration include reports prepared by or for the Department of Fisheries and Oceans (Gordon et al. 2000; DFO 2004b and e), Environmental Studies Research Funds (Buchanan et al. 2003), and the Canadian Environmental Assessment Agency (Hurley and Ellis 2004). Two reports funded by the oil and gas industry describe the general environmental effects of seismic surveys (Davis et al. 1998) and exploratory drilling (Thomson et al. 2000) on the Scotian Shelf.

In 1999, a DFO Regional Advisory Process (RAP) was carried out to generate a peer-reviewed summary of the Georges Bank ecosystem and potential impacts from petroleum exploration activities. With respect to exploratory drilling, it was concluded that routine operational exploratory drilling activity is likely to have only localized impacts on the ecosystem components reviewed (Boudreau et al. 1999). It was also concluded that exploration drilling would lead to a temporary loss of access to some portion of the fishing grounds, although the area lost would be relatively small. A low probability of a large release of petroleum product from a well blowout also exists. If such an incidence occurred it could potentially have population and ecosystem level impacts.

A workshop on the environmental effects of offshore hydrocarbon development was held at the Bedford Institute of Oceanography, March 2-3, 2000. The purpose of the workshop was to share information on relevant research, industry sponsored Environmental Effects Monitoring (EEM) programs, review lessons learned to date, and to discuss the way forward. It was recognized that an extensive scientific database on the effects of offshore hydrocarbon development is available from other regions, especially the North Sea and the Gulf of Mexico, and that basic principles can be applied from one region to another (Gordon et al. 2000).

The generic assessment of the effects of exploratory drilling on and adjacent to the Scotian Shelf (Thomson et al. 2000) used a scenario approach based on five sites representing different areas to evaluate impacts.

In 2003, LGL Ltd. and CEF Consultants Ltd. prepared a review of environmental effects monitoring programs on the East Coast for the Environmental Studies Research Funds. The study reviewed information obtained from monitoring programs and interviewed industry, government and stakeholder contacts concerning the potential impacts from exploratory drilling and the effectiveness of monitoring programs (Buchanan et al. 2003).

Hurley and Ellis (2004) continued the review of environmental effects monitoring for exploratory drilling through a data and literature review for the Canadian Environmental Assessment Agency.



In 2004, DFO produced two reports on the impacts of seismic surveys. DFO (2004b) summarized the Department's view of scientific information related to the impacts of seismic sound on fish, invertebrates, marine turtles and marine mammals. DFO (2004e) described the results of specific environmental effects monitoring of a seismic survey off western Cape Breton on snow crab.

6.2 Results of Consultation

As an integral component of this SEA, a consultation process was developed to include a variety of organizations and stakeholders. These groups (see Table 6-1) were identified through the CNSOPB Fishery's Advisory Committee and the DFO's consultation lists. A broad range of issues and concerns were raised during this process. The main concerns of stakeholders, including those raised by the crab and shrimp fisheries, conservation groups, and First Nations, are described in more detail below.

Fisheries groups expressed numerous concerns about the potential impacts of oil and gas activities on their industry, most notably the potential effects of seismic surveying on the snow crab fishery. Concerns were raised about the scarcity of scientific knowledge of snow crab biology and migratory patterns in the SEA area. Other issues, such as existing quota allocations, current fishing pressure, and declining stocks, have caused stakeholders to question the overall health of the snow crab fishery. These issues are of particular concern in sensitive sites such as the Louisbourg Hole and other fishing holes in and around Misaine Bank.

The shrimp fishery expressed concerns about opening the Misaine Bank area to oil and gas exploration and development because the largest proportion of shrimp biomass is expected to be in this area (Louisbourg Hole and other holes in and around Misaine Bank) for the next one to three years. Potential conflicts with oil and gas activities during sensitive and important seasons related to both the fishery and biology of the shrimp were raised. Vulnerability of shrimp to seismic activity during their reproductive and soft-shelled stages was questioned.

NGOs, particularly the World Wildlife Fund (WWF) and the Ecology Action Centre (EAC), emphasized the current lack of scientific study in the Misaine Bank. The SEA area, due to its topography, may represent unique habitat and associated biodiversity, such as deep sea corals, which occur in the adjacent Laurentian Channel. A moratorium on development on the Eastern Shelf was recommended by NGOs, in order to fully integrate the SEA into the developing ESSIM initiative and to further explore the potential for designation of a Marine Protected Area in the SEA area.



Table 6-1: Stakeholder Consultations for the Misaine SEA

Organization	Type of Issues Represented
Area 21 to 24 Snow Crab Fishermen's Associations	Fishing activity and sustainability
C.R.A.B.	Fishing activity and sustainability
Atlantic Canadian Mobile Shrimp Association	Fishing activity and sustainability
Atlantic Herring Co-op	Fishing activity and sustainability
Bedford Institute of Oceanography	Research Surveys
Canso Fishermen's Co-operative	Fishing activity and sustainability
Clearwater Fine Foods	Fishing activity and sustainability
C.R.A.B.	Fishing activity and sustainability
Confederacy of Mainland Mi'kmaq	Interests of Aboriginal Peoples
Atlantic Canadian Mobile Shrimp Association	Fishing activity and sustainability
East Cape Breton Fishermen's Association	Fishing activity and sustainability
Eastern NS Mobile Gear Association	Fishing activity and sustainability
Eastern Fishermen's Federation AND Eastern Shore Fishermen's Protection Association	Fishing activity and sustainability
Ecology Action Centre	Environmental protection
Guysborough County Inshore Fishermen's Association	Fishing activity and sustainability
Maritime Fishermen's Union	Fishing activity and sustainability
Membertou First Nation	Interests of Aboriginal Peoples
Netukulimkewe'l Commission (Native Council of Nova Scotia)	Interests of Aboriginal Peoples
Nova Scotia Sword Fishermen's Association.	Fishing activity and sustainability
Richmond County Inshore Fishermen's Association	Fishing activity and sustainability
Sambro Fisheries	Fishing activity and sustainability
Scotia Fundy Mobile Gear Fishermen's Association	Fishing activity and sustainability
Seafood Producers Assoc. of NS	Fishing activity, processing and sustainability
Sierra Club of Canada	Environmental protection
Slope Snow Crab Fishermen	Fishing activity and sustainability
Unama'ki Institute of Natural Resources	Interests of Aboriginal Peoples
W.T. Grover Fisheries	Fishing activity and sustainability
Wagmatcook First Nation	Interests of Aboriginal Peoples
Waycobah First Nation	Interests of Aboriginal Peoples
World Wildlife Fund	Environmental protection

First Nations in the area are represented by the Confederation of Mainland Mi'kmaq and the Union of Nova Scotia Indians, both of whom work cooperatively through the Assembly of Nova Scotia Chiefs. The Confederation has requested to consult directly



with the Crown (provincial and federal levels). These consultations are of a legal nature regarding benefits and legal rights and have no particular bearing on the information gathering process of the SEA. To address this issue, a First Nations Traditional Knowledge Study was recommended in addition to engaging in consultation with the Union of Nova Scotia Indians who is not currently represented in the SEA process.

Oil and gas exploration has the potential to interfere with some research activities, notably DFO science surveys that are designed to measure abundance. This SEA looks to the future beyond which these surveys are planned, but project specific EAs can request research survey schedules and locations from DFO to ensure interference does not occur. DFO was contacted as part of the consultation process in relation to research programs and emerging fisheries that may occur but are not currently captured by the catch and effort system.

6.2 Issues Scoping and Selection of Valued Ecosystem Components

6.2.1 Issues Scoping

Issue scoping is an important part of the issue identification process. Scoping included the following:

- stakeholder and regulatory review and comment on the draft scoping document;
- review of regulatory issues and guidelines;
- review of previous environmental assessments for offshore oil and gas exploration, including previous SEAs on the East Coast, and
- research of publications on specific issues of concern.

6.2.2 Boundaries

The administration boundaries for this SEA are described in Section 1.2, Rationale for this SEA.

The spatial boundary for this assessment is the proposed SEA area and the adjacent area within which adverse impacts could be reasonably expected to occur. Definition of the SEA area incorporated a minimum distance to shore of 30 kilometres. The eastern coast of Cape Breton is considered within the scope of this project in relation to possible hydrocarbon spills in association with exploration drilling. From an ecosystem perspective, information is focused within the SEA area but compared to the eastern Scotian Shelf, Sydney Bight, and the Laurentian Channel.

Temporal boundaries for the assessment are limited to the oil and gas exploration phase; insufficient information on the types of hydrocarbon resources and potential development



options are available to assess possible development impacts. Opening of the area for exploration will also take time. Review of this SEA, preparation of a possible call for bids, submission of bids and review, could take a number of years. For historic comparison, fisheries data from the early 1990s (pre-moratorium) are included to provide insight into possible future changes in the current fisheries.

6.2.3 Selection of Valued Ecosystem Components

Based on the results of stakeholder consultations, a review of the regulatory issues and guidelines, other environmental assessments for oil and gas exploration projects (e.g., the generic assessments), and the professional judgment of the study team, a list of Valued Ecosystem Components (VECs) were selected for this assessment:

- marine fish and invertebrates;
- commercial fish species (e.g., snow crab and shrimp);
- benthic communities and fish habitat;
- fish and invertebrate eggs and larvae;
- fisheries and fishing activity;
- sea and coastal birds;
- species at risk;
- marine mammals and sea turtles;
- air quality, including greenhouse gas emissions, and
- special areas.

The VEC selection process looks at the range of ecosystem components that could be affected by exploration activities. These include fundamental and widely distributed components such as plankton and birds. During the assessment process current knowledge is assessed and potential pathway linkages determined. The final selection is based on the role of the ecological component in combination with potential pathways. If an impact pathway is not identified, the component is not included as a VEC.

It is recognized that plankton is the basis of the marine ecosystem and that impacts to plankton could have ripple effects throughout the system. However, the proportion of plankton exposed to lethal impacts is so low that it is not conceivable that a significant impact could be foreseen. Thus, plankton is not included as a VEC in this analysis.

Inclusion of water and sediment quality as specific VECs was considered during scoping. Water quality on the Scotian Shelf, including Misaine Bank, is essentially a function of the dynamic physical oceanography and is typically characterized by temperature and salinity profiles. The impact of contaminant discharges or other exploration activities are usually considered in relation to effects on organisms, such as fish, to conform to requirements of the Fisheries Act. In production scenarios, specific concerns, such as the



discharge of NORMs (Naturally Occurring Radioactive Materials) in produced water, are independent of a target organism. However, these types of discharges are not normally associated with exploration activities.

A similar argument can be made for sediment quality. Impacts of exploration activities, such as the potential discharge of muds and cuttings from drilling, are traditionally evaluated in relation to impacts on benthic communities. Guidelines for sediment quality are relevant where ocean disposal regulations are triggered, as was the case with the Cohasset Decommissioning. Activities associated with exploration, in general, do not trigger these guidelines. Discharge of contaminants related to exploration activities, affecting water or sediment, will be assessed for potential impacts by focusing on final receptors of concern.

6.3 Environmental Effects Assessment Framework

The *CEA Act* defines valuation criteria for the significance of adverse residual (post-mitigation) environmental effects. These criteria include, among other factors:

- magnitude;
- geographic extent;
- duration and frequency;
- reversibility; and
- ecological context.

Environmental standards, guidelines and objectives are also used to establish significance.

Where existing knowledge indicates that an interaction is not likely to result in an effect, certain issues may not warrant further analysis. Mitigative measures are considered in the analysis, and the residual effect on VECs predicted. In cases where results are likely to result in an effect, the prediction of residual effects follows three steps:

- determining whether the environmental effects are adverse;
- determining whether the adverse environmental effects are significant; and
- determining whether a significant environmental effect is likely to occur.

The effects assessment for each VEC concludes with a summary of the residual environmental effects.

6.3.1 Data Deficiencies

Most information on eggs and larvae dates from the SSIP surveys undertaken in the late 1970s and early 1980s. Since then, changes in relative species abundance and, at least for cod, shifts in spawning activity, have been observed. Fortunately, the Misaine SEA area



is not an area where finfish spawning is concentrated compared to other parts of the Scotian Shelf.

The Misaine SEA area is an important area for commercial fishing of snow crab and shrimp. The effects of seismic survey operations on snow crab has been specifically evaluated off Newfoundland and western Cape Breton, but little information exists on the effect of seismic operations on shrimp. Reproduction of both snow crab and shrimp may be important within the SEA area, but little information exists on seasonal migrations of snow crab or mating within the SEA area. The effect of drilling wastes has focused primarily on sea scallop, and the evaluation of impacts in the Misaine Bank SEA area will depend in part on how applicable these studies are to crab and shrimp.

6.4 Environmental Planning and Management

The SEA examines potential environmental impacts at the regional level to determine if oil and gas exploration should be opened for exploration licensing, and if specific planning and management steps should be taken to minimize potential impacts. This is also the first SEA to be completed following release of the Draft ESSIM Plan, which provides guidance on integrated ocean management for the area. This SEA will focus on identifying specific ecological or human use issues within the SEA area, which differ from other parts of the Scotian Shelf where oil and gas exploration has been permitted. It will also examine where measures may be implemented at the regional level to minimize impacts of this type of exploration. Additional measures may be identified based on specific sensitivities of the SEA area identified through review of the environmental setting or through advances in our general understanding of potential effects and mitigating measures.

7 EFFECTS ANALYSIS

7.1 ESSIM and Criteria for Ecological Significance

Canada's *Ocean Act* became law in December of 1996. This Act and its supporting policy, Canada's Oceans Strategy, affirm DFO's mandate as the lead federal authority for oceans and provides the national policy context for integrated ocean management. To promote integrated ocean management, a prototype oceans management plan has been developed for the Eastern Scotian Shelf (DFO 2005b). The ESSIM (Eastern Scotian Shelf Integrated Management) Draft Management Plan provides general guidance on assessing ocean impacts related to oil and gas exploration, and thus provides important guidance to this SEA.

The ESSIM Draft Management Plan contains specific reference to oil and gas environmental impact assessment and regulation. Under consideration of Marine



Ecosystem Management and Conservation, the plan requires development of an objectives-based framework that applies ecosystem objectives to oil and gas environmental assessments, and exploration and development planning. In addition, DFO and Environment Canada identify ecologically and biologically significant areas. Development and implementation of the regional coral conservation plan is also linked to oil and gas exploration. In relation to the benthic community ecosystem and habitat issues, the EESIM draft plan suggests a conservation plan for protection be developed to deal with oil and gas industry issues (DFO 2005b).

Specific to seismic surveys, the ESSIM plan requires incorporation of national standards and procedures for mitigation of impacts into the regional regulatory process. The plan suggests mitigation should be developed for other marine sound-generating activities, including exploration and production drilling. It also supports continued collaborative research by DFO, NRCan, Environment Canada, and the CNSOPB into effects of sound on fish, invertebrates, marine mammals and turtles. Continued assessment of cumulative impacts is also suggested, along with development of a high-resolution circulation model by DFO to support environmental assessments, monitoring and decision making (DFO 2005b).

7.1.1 Ecological Significance

DFO prepared a discussion paper on ecologically significant areas on the Scotian Shelf and Slope in 2004 (Breeze and Maris Consulting 2004). It relied on a definition of ecological significance from another parallel initiative by Schaefer et al. (in press):

Ecologically significant areas are those which have valued ecological attributes. Valued ecological attributes contribute to the functioning and sustainability of the ecosystem, the maintenance and conservation of genetic, species, population and/or habitat diversity, and/or other similar vital ecological functions. These attributes are present to a higher degree than most/all other areas within the region.

These attributes may be valued for their use by humans (both direct and indirect), such as when they contribute to sustainability of a commercial fishery. Or they may be valued simply for their existence or bequest value, such as when something is valued because it can be passed on to future generations.

Criteria proposed for selection of ecologically significant areas include:

As first-order criteria:

- biological productivity;
- biodiversity (species and genetic diversity);
- reproductive areas;
- migration or bottleneck areas (non-reproductive);



- habitat for endangered/threatened species;
- rare/unique habitats and habitat for rare species, and
- naturalness.

And as second-order criteria:

- dependency/survival;
- fragility/sensitivity, and
- significance in terms of scale.

Appropriate indicators were also identified for each of these criteria. Examples of indicators include high surface chlorophyll concentrations as an indicator of biological productivity, or areas that are a refuge from human activity because of difficult access as an indicator of naturalness.

7.1.2 Initial Evaluation of the Misaine SEA Area

Breeze and Maris Consulting (2004) provide an analysis of the ecological sensitivity of the majority of the Misaine SEA area (Table 7-1).

The review carried out by Breeze and Maris Consulting (2004) included an analysis of areas that were little affected by past bottom trawling activity and could thus represent more 'natural' areas. Misaine and Canso Banks, along with the Western Gully, were identified as areas where little trawling traditionally occurred. The review concluded that the shrimp and snow crab were fished in the deeper colder holes, but that red crab, Jonah crab, scallop and surf clam were not fished on Misaine Bank. While the area was ranked as more natural than most other areas, less information was available on the ecology of Misaine and Canso Banks than on other parts of the Scotian Shelf. Potential recovery time after disturbance was raised as an issue, but neither appeared ecologically significant in an initial review of available information.



Table 7-1: Ecological Sensitivity of Areas within the Misaine SEA Area

Area	Information Availability	Criteria	Potential High Value (Yes/No)
Misaine Bank	Poor	Biological productivity	No
		Biodiversity	No
		Reproductive areas	No
		Bottleneck areas	No
		Habitat for endangered/threatened species	No
		Rare/unique habitats and species	No
		naturalness	No
Shrimp Holes near Misaine and Canso Banks	Poor-Fair	Biological productivity	Yes
		Biodiversity	No
		Reproductive areas	Potentially
		Bottleneck areas	No
		Habitat for endangered/threatened species	No
		Rare/unique habitats and species	No
		naturalness	No

Deeper shrimp holes, including the large Lousibourg Hole, are found north and south of Misaine Bank. Breeze and Maris Consulting (2004) found these areas to be important in terms of biological productivity, and potentially as a reproductive area. High organic content of the fine silt bottom sediments are a major factor in the high biological productivity. The area appears to act as a source of larvae for areas of the Shelf to the southwest. In addition to fishing for snow crab and shrimp, the areas fall within MARLANT exercise areas Q2 and Q3. Again, the level of information on the ecology of these holes was less than for most of the Shelf.

In addition to these two areas, the edge of the Laurentian Channel is known to be a major migration route for marine mammals in and out of the Gulf of St. Lawrence, and overwintering area for many finfish, and in some channels and canyons, an area of deep sea corals. None of the Misaine SEA area, however, is known to be particularly ecologically sensitive.

7.2 Seismic Surveys

Potential impacts from seismic surveys have been described in a generic assessment of seismic survey impacts on the Scotian Shelf (Davis et al. 1998) and a more recent review by DFO (DFO 2004b). Overall, pathways for environmental effects related to seismic surveys on the Scotian Shelf include:



- injury from pressure waves;
- disturbance or masking of communication by noise leading to behavioural change; and
- interference with marine vessel traffic, particularly fishing vessels and gear.

Impacts associated with the following issues will be addressed for each VEC:

- effects on special places;
- effects on fish and invertebrates, and fish/invertebrate eggs and larvae;
- effects on marine mammals and turtles, and
- effects on fishing activity.

Some seismic surveys are conducted using oil-filled streamer lines, and ruptures releasing oil into the local marine environment have occurred. Losses of hydrocarbons, principally kerosene, ranged from 0.009 to 0.57 m³ in 14 incidents between 2003 and 2004 (CNSOPB Environment Spill Reporting). Only one incident occurred in 2004. All incidents were classified as minor.

Vertical Seismic Profiles (VSPs), essentially small scale seismic surveys, may be done during exploratory drilling. These profiles use airgun arrays similar to regular seismic surveys, but are generally very localized (one or two lines within a couple of kilometres of the rig) and of short duration (one day). Any effects from VSPs would be covered by the discussion of seismic surveys in general.

7.3 Exploratory Drilling

Potential effects from exploratory drilling include impacts resulting from routine activities, and those occurring from accidental releases of hydrocarbons. Pathways through which routine activities may impact the receiving environment include:

- presence of structures;
- lights and flares;
- disturbance and noise;
- routine discharges; and
- discharges of drilling muds and cuttings.

The pathway for impacts of most concern is the accidental release or uncontrolled discharge of oil, condensate, gas, or gas hydrates into the marine environment. Other small accidental releases of contaminants may also occur.

The vast majority of offshore wells are drilled without incident. However, there is a relatively small probability of an accident occurring that results in the release of hydrocarbons into the environment.



Historically, one blowout has occurred for every 180 exploration wells drilled on the United States Outer Continental Shelf (S.L. Ross 2001). The chances are extremely low that spilled oil would be involved, even in small amounts. If a blowout did occur, chances are that it would last only a short time. Thomson et al. (2000) noted that approximately 21% of offshore blowouts are brought under control in less than 1 hour, 58% were controlled in less than 1 day, and 84% in less than one week.

Recent reports of spills reported to the CNSOPB are summarized in Table 7-2.

Table 7-2: Spill Incidents Reported to the CNSOPB, 2002-2004

Year	Number of Spills	Classification	Description
2004	6	Minor	Gas, hydro carbons, Iospar M, oil, Shell tellus 46, diesel
	1	Significant	Synthetic drilling mud (331 m ³)
	1	Moderate	Diesel fuel (4 m ³)
2003	30	Minor	Hydraulic oil, MEG, Isopar M, hydraulic fluid, Streamer fluid X, keosene, Synthetic based mud, hydrocarbon, residual fuel, lubrication oil, oil, KCL/methanol/grease, diesel.
	1	Significant	MEG and Hydrate inhibitor (20 m ³)
2002	21	Minor	Oil, SBM, WBM spacer, natural gas, hydraulic oil, hydrocarbon, condensate, light oil.
	1	Moderate	Conduit line fluid (7.29 m ³)

Improvements in performance can no doubt be achieved and monitoring and reporting should continue. However, this level of contamination of the marine environment is minor compared to ongoing discharges of oily wastes from shipping passing through the area (CEF 2004). About 300,000 seabirds are killed each winter in the waters of Atlantic Canada by chronic operational discharges of oil at sea (Wiese 2002).

7.4 Potential Effects on VECs

The following sections describe the general effect of seismic surveys, exploratory drilling, and well site surveys on the VECs identified in Section 6.2.3. Each of these impacts will be examined in detail in environmental assessments prepared for a specific project where more site-specific analysis can occur. The following section deals with the particular sensitivities of the Misaine SEA area in comparison to other parts of the Scotian Shelf and Laurentian Channel where oil and gas exploration is already ongoing.

7.4.1 Seismic Surveys

The principle concern associated with seismic surveys is the effect of underwater noise on marine organisms, ranging from the direct mortality of eggs and larvae within five metres of the airguns, to disruption of fish spawning activities and marine mammal



migrations. A detailed discussion of these impacts is provided in Thomson et al. (2000). This review has been updated by DFO (2004b). Both sources have been used to prepare the following summary of impacts.

Considerable study of the effect of airgun discharge on eggs and larvae of a wide range of species has been undertaken. Beyond a distance of approximately five metres, no impact is observed (Thomson et al. 2000). The scientific community is in general agreement that the potential for significant impact on eggs and larvae is unlikely unless they happen to be very concentrated within the lethal range of the airguns, which is highly unlikely (Thomson et al. 2001; DFO 2004b).

For finfish, no direct mortality has been observed from seismic survey operations, but changes in behaviour have been well documented in various studies. Effects include a startle response, change in swimming behaviour, and a change in vertical distribution with fish frequently moving close to the bottom (DFO 2004b). These changes are usually short term, lasting over a matter of days, and may extend about 30 kilometres from the sound source (Jacques Whitford Environment 2003). Sublethal effects have been observed with exposure at relatively short range (less than one kilometre), but these effects are not directly life threatening and recovery may occur (McCauley et al. 2003). Potential effects on spawning, either through disruption of behaviour or masking of communication, are considered the highest potential risk for impact leading to reduced abundance (DFO 2004b).

In relation to shellfish, available evidence suggests that macroinvertebrates are less vulnerable to these types of injury because few invertebrates have internal air spaces, such as air bladders in many fish (Jacques Whitford Environment 2003). The balance structures in invertebrates, such as the statolith in snow crab, are also simpler than ears in fish, and thus may be less vulnerable to injury. Behavioural effects, similar to those on fish, may also occur (DFO 2004b). A more detailed discussion of this work is provided in Section 7.5.4.

Effects on sea turtles and marine mammals generally relate to behavioural effects, such as disruption of feeding or migrations (DFO 2004b). Sublethal effects, specifically injury to ears, are more likely to happen with the slower swimming sea turtles. Marine mammals and sea turtles are expected to avoid active seismic survey sound sources and not suffer injury.

7.4.2 Exploratory Drilling

7.4.2.1 Presence of Structures

Migrating birds could be attracted to and land on offshore drilling platforms and supply boats. It is also possible that large numbers of shorebirds may fly over the area during their southward migration. However, protocols have been developed to handle birds that land on vessels or rigs to minimize any impacts, and the frequency of events has



remained relatively low. Impacts on marine and terrestrial birds caused by the presence of structures are expected to be minimal.

Navigational, warning, and working lights on the rigs and supply vessels can attract nocturnal birds, especially during foggy or overcast conditions. Minimal impacts have been reported from existing rigs or supply vessels on the East Coast.

Flares pose more of an immediate danger because in addition to attracting birds, they can physically harm them. However, flaring during exploration only occurs for short periods, and only if hydrocarbons are found.

Sub-sea structures, such as the legs of jack-up rigs, can alter the local distribution of fish because of attraction to reef-like structures. Epifauna will gradually develop on these structures, increasing their attractiveness. However, the relatively short duration and limited sub-sea components of a rig drilling an exploration well would not lead to any significant effects (Hurley and Ellis 2004).

For safety reasons, an exclusion zone extends 500 m around a rig. This exclusion zone would have minor impacts on the fishery, but possibly a significant impact on a few individual fishers if they rely on a small area for a large proportion of their catch.

Most rigs are fairly quiet because the machinery is located above the water surface. The incremental sound made by supply boats and an individual drilling rig would not add significantly to existing ambient noise levels. Thus, impacts on fish, marine mammals and birds are expected to be negligible to minor.

Once an exploratory well is tested, it is usually abandoned and the wellhead is removed to prevent any seafloor obstructions. This usually involves plugging the well and cutting the well casing just below the surface of the seafloor. An ROV survey is done to ensure there are no seafloor obstructions that could snag fishing or other gears.

7.4.2.2 Routine Discharges

There may be up to 100 people on a drilling rig at any given time, and discharges of gray (e.g., deck drainage and showers) and black (sanitary waste) water occur. Due to the relatively small amount of discharged organic matter and nutrients, the impacts on receiving waters have been determined to be negligible in the past.

Other types of routine discharges and treated oily wastes, including ballast water, bilge water, deck drainage, discharges from machinery spaces, and cooling water, are generally transported ashore for treatment and disposal. If, however, discharge into the marine environment does occur, wastes are treated as per the Offshore Waste Treatment Guidelines before disposal. Impacts of treated oily wastes on the marine environment are expected to be negligible.



7.4.2.3 Air Discharges

Sources of air discharges include fugitive emissions (barite and cement dust, halons, and volatile organic compounds) and operational emissions (vessel exhaust, exhaust fumes from diesel generators, and flaring). If well testing occurs, flaring is the largest likely emission source from exploration drilling. Emissions estimates from flaring are highly variable and dependent on flaring rate, flaring time (hours/days of flaring), and gas composition.

Experience in the Nova Scotia offshore area over the past three decades provided the assumptions used to create Table 7-3. An assumed flaring time and rate of 24 hours and 560,000 m³/day, and a value of 5 ppm H₂S were used in the calculations. Estimates of gas composition (emission factors) were obtained from previous work (Devon 2004).

Table 7-3: Emissions Associated with Flaring for One Well

Pollutant	Emission Factor(kg/1000 m ³)	Total Emissions(tonnes)
NO _x	1.1	0.616
SO ₂	0.27 *(H ₂ S in ppmv/100)	0.00756
PM _{2.5}	0.61	0.342
Benzene	0.0025	0.0014
Total PAHs	0.000048	0.000027
CO ₂ (CO ₂ E)	1913	1100
CH ₄ (CO ₂ E ²)	0.04*23	0.515
N ₂ O (CO ₂ E ²)	0.04*296	663

Emissions from the drilling platform and associated equipment (generators etc.) would likely be the next largest emissions source. Estimates of carbon dioxide of up to 22,443 tons/well for a drill ship and 16,161 tonnes per well were estimated for a recent drilling project assuming a typical operation lasting 90 days (CNSOPB 2005).

The typical emissions from flaring are less than the longer-term emissions from a drill ship and supply vessels. The potential impact of these air emissions is typical of larger marine operations normally operating within Atlantic coastal waters and does not justify detailed analysis in environmental assessments for specific exploration projects, but the issue should be mentioned in discussion of cumulative impacts.

7.4.2.4 Muds and Cuttings

Typically, a small mound of cuttings and mud form directly below the drilling rig. Modeling carried out for the generic assessment indicates that the small quantities of cuttings involved in exploratory drilling at the depths likely encountered in the Misaine SEA area result in mounds tens of metres in diameter, smothering benthic organisms over an area of a few hundreds of square metres (Thomson et al. 2000; Buchanan et al. 2003).



Recovery of the benthic community may occur within months or may take up to a year (Buchanan et al. 2003).

Contaminants discharged with WBM (Water Based Mud) have been shown to sometimes increase heavy metals in sediments within 250 to 500 m of the drill site, but these metals are not in a bioavailable form and biological effects have been minor. If SBMs (Synthetic Based Muds) are used, smothering still appears to be the main effect, but SBMs tend to clump cuttings together more than WBMs, reducing dispersal (Buchanan et al. 2003).

In addition to smothering, small quantities of drilling wastes are carried across the seabed by bottom currents. The general fate and effects of drilling wastes are discussed by Milligan et al. (1996). The sea scallop (*Placopecten magellanicus*) is a suspension feeder and generally considered a sensitive and valued benthic species. The observed effects of WBMs and dispersion wastes are associated with the impairment of feeding processes, not direct toxicity. The chronic lethality of low levels ($>10 \text{ mg l}^{-1}$) of WBMs was very low; scallop mortality in these exposures was similar to the controls in which no drilling wastes were added (Cranford et al. 1999).

Buchanan et al. (2003) also noted that cement may be discharged to the marine environment during exploratory drilling. Quantities of up to 26 m^3 have been released and, if it forms a hardened pile, will act as an artificial reef and be colonized by epifauna.

7.4.2.5 Settlement and Dispersion of Drilling Wastes

Impacts on the benthic community can occur from cuttings and mud that accumulate in a pile below the drill rig (nearfield), or over relatively long distances from dispersion of fines within the benthic boundary layer (farfield). The generic assessment (Thomson et al. 2000) predicts that discernable effects on the benthic communities would be limited to an area of a few 100 m from the source.

7.4.3 Well Site Surveys

Prior to setting up most rigs, a well site or hazard survey will be conducted to make sure conditions will support the rig legs (or spuds) or anchors, and that there are no potential shallow gas accumulations in the near surface that the well bore would penetrate. Well site surveys acquire high-resolution seismic data, sub-bottom profiles; side scan sonar images and bathymetry concurrently. Grab samples and bottom camera photographs are usually taken where appropriate. The actual geometry of the surveys may be adjusted during acquisition to account for water depth. The choice of sub-bottom profiler (shallow or deep tow) is dependent on water depth.

The impacts of well site surveys are extremely localized. Effects of the seismic and sub-bottom profiler systems are similar to those of a large scale seismic survey, but only occur for a short period of time (hours) over a very localized area, e.g., hundreds of square metres.



7.4.4 Potential Effects on Fisheries

Concerns about the effect of oil and gas exploration on fisheries are integrated into this section because many of the concerns are common to both seismic surveys and exploratory drilling. Both activities involve vessels traversing valued fishing areas. Concerns include:

- loss of access and exclusion zones around rigs;
- interference with fishing activity, particularly interference between drift longlines and seismic streamers;
- communication and navigation safety;
- damage to gear, particularly floats for fixed gear, which results in loss of gear;
- reduced fish and shellfish catches;
- potential tainting of catch and subsequent loss of market, and
- potential oil spills.

Most recently, specific concern has been raised about potential effects of seismic sound sources on snow crab, which is dealt with in the following section.

7.5 Special Sensitivities of the Area

Key sensitivities of the SEA area related to potential interactions with oil and gas exploration are:

- naturalness of the area (limited bottom trawling);
- productivity and reproduction;
- lack of information on benthic communities;
- differing views on potential impacts on lucrative commercial fisheries for shrimp and snow crab;
- potential for deep water corals;
- sensitive coastal areas (affected by accidental spills of hydrocarbons), and
- potential adverse impacts on species of concern under SARA.

Each of these issues are examined in relation to opening the Misaine SEA area to exploration and the potential for mitigation.

7.5.1 Naturalness

The topography and surficial geology of the Misaine SEA has limited bottom trawling in the area, which has tended to preserve its naturalness compared to most other parts of the Scotian Shelf (Breeze and Maris Consulting 2004). Specific areas, however, have not been identified as needing protection. The effect of oil and gas exploration is of relatively



short duration and limited spatial impact compared to the large-scale bottom trawling that has occurred over much of the Scotian Shelf. Project specific environmental assessments, including cumulative assessments, should consider potential effects on naturalness within the SEA area.

7.5.2 Productivity and Reproduction

The deep shrimp holes around Misaine Bank are noted for their productivity, and the area in general is thought to supply shrimp larvae across the Shelf (Breeze and Maris Consulting 2004). The productivity appears to be primarily associated with the high organic content of the silt deposits in the deep holes. Generally bottom temperatures in the area are cold, tending to restrict productivity.

The deep shrimp holes are also important for snow crab, and some reproduction may occur in this area. Crab fishermen reported in consultations that they feel Louisbourg Hole is an important area for reproduction of snow crab, but clear evidence of its role is not available from DFO survey data.

7.5.3 Lack of Information on Benthic Communities

Mapping of benthic habitat is more limited than in many other parts of the Scotian Shelf. Natural Resources Canada took bottom grabs for benthos on their 2002 survey, but coverage was poor. Multibeam or sidescan mapping isn't available, and thus benthic samples could not be integrated into a broad habitat classification system and mapped. DFO has not carried out any recent benthic habitat surveys of the area.

The undulating topography of the area provides a degree of isolation between benthic communities, increasing the potential for genetic diversity. The area also serves as a refugia from human activities, further increasing diversity. Unfortunately, available information is too limited to evaluate the degree to which genetic diversity may be higher in the area.

7.5.4 Concerns About Impacts on Shrimp and Crab Fisheries

An Environmental Studies Research Fund (ESRF) study was carried out off southern Newfoundland in 2002 (Christian et al. 2003) to provide specific information on the impacts of seismic airgun discharges on snow crab. Fishermen from many parts of Atlantic Canada had expressed concerns about possible impacts on their highly valuable fishery. Results of the study indicated no direct mortality or obvious effects on adult crab behaviour, health, or catch rates. However, questions remained about sublethal impacts, particularly on eggs and gonads, which could affect future reproduction.



Questions about possible sublethal effects and a requirement to conduct environmental effects monitoring guided design of a monitoring program of a small¹ seismic survey conducted off western Cape Breton in November of 2003. The study used caged crabs and examined short-term (12 days) and medium-term (five months) differences in the behaviour, morphology and physiology of snow crab at test and control sites. Snow crabs from both groups were also observed under laboratory conditions for differences in mortality, conditions and behaviour over a six-month period (Chadwick 2005).

Results of the study showed no significant difference in mortality or external morphology between test and control sites. However, antennules, statocysts, gill characteristics, hepatopancreas and ovarian structures did differ between the two sites, with test sites showing abnormalities (Chadwick 2005). Antennules, gills, and statocysts returned to normal within five months. Changes to the hepatopancreas and ovaries suggested subtle, long-term effects may have occurred. Peer review indicated that the results of the study could have been a result of the experimental design or indicative of real but subtle impacts from the seismic airgun discharges (Chadwick 2005).

Species specific studies have not been done to document the impact of seismic surveys on shrimp; leading to a similar situation with the commercial shrimp fishery. Effects are expected to be minor, based on interpolation from other information on other invertebrates. Northern shrimp do not make noise, eliminating a concern of possible masking of communication (Koeller, P., DFO Science, pers. comm., 2005).

Crab and shrimp fishermen are concerned about potential risk to their livelihood. They are logically resistant to accepting any risk, and work to minimize their exposure. The current restructuring in the crab fishery (Gardner et al. 2005) further complicates the issue and raises tensions.

One view of the current situation with respect to snow crab is that two specific studies (Christian 2003; Chadwick 2005) have been conducted that were unable to document any specific problem. An opposing view is that questions remain and there is a risk of long term impacts on recruitment to the fishery. Viewing the snow crab as a common property suggests that a comparison of the potential effect of commercial fishing versus seismic surveys on the crab population might be reasonable.

Reported landings for eastern Nova Scotia were 9,629 tonnes in the 2004 fishing season, and fishable biomass reduced 41% in Sydney Bight and 15% on the Scotian Shelf over the year (DFO 2005a). The potential effect of seismic surveys results in no immediate

¹ The survey used a low power array. In situ measurements at the site indicated sound levels of 190 dB re μ Pa at 236 m, and a maximum rms sound pressure level of 178 dB re μ Pa was observed at the caged snow crab test site (Chadwick 2005). Standard seismic survey airgun arrays tend to use sound pressure levels of about 260 dB re μ Pa.



mortality and at worst has only a subtle longer-term effect. At the same time, the Misaine SEA area may be important to reproduction of both snow crab and shrimp, increasing the vulnerability of an exceedingly valuable fishery.

Consultation has suggested fishermen of both snow crab and shrimp, as well as ENGOs, would like to see a prohibition on oil and gas exploration in the area until more information is available. A compromise position that appears reasonable would be to exclude the Louisbourg Hole from the Misaine SEA area, because of its potential importance both ecologically and for commercial fishing, until more detailed studies are undertaken to allow more quantification of the value of the area and the potential for adverse effects.

7.5.5 Deep Water Corals

Deep water corals are known to occur in canyons and fans along within the Laurentian Channel. The Stone Fence off Banquereau Bank has been identified as an important coral area and is now protected, but no areas have been identified within the Misaine SEA area. St. Ann's Bank and Artimon Bank, near Misaine bank, have been identified as areas where deep sea coral occur based on fishermen's local ecological knowledge (Gass 2004). However, the deeper water holes closer to Misaine Bank have been identified as priority areas for research related to corals (DFO 2005c). It will therefore be critical that well site surveys include a thorough reconnaissance component to determine if corals are present.

7.5.6 Sensitive Coastal Areas

Specific sensitive ecosystem areas or special management areas, such as marine protected areas, are not located within the Misaine SEA area. However, numerous highly sensitive areas, including sandy beaches, national historic sites, such as Fortress Louisbourg, and important bird colonies, are located along the eastern coast of Cape Breton. The potential for impact on these sensitive coastal area is limited to accidental events, where hydrocarbons are carried ashore by wind, waves and currents.

To evaluate the potential for hydrocarbons to reach this vulnerable shoreline, a number of trajectory simulations were run, as outlined in Section 3.3. Trajectories for the four seasons are presented in Figure 7-1.

The trajectories illustrate the dominant effects of offshore winds and the Nova Scotia current, which operate to carry surface spills away from the coast. Winds could push a spill towards the coast, but it is unlikely that they would persist in a shoreward direction for long enough to drive large volumes of oil ashore given a minimum distance of 30 kilometres.



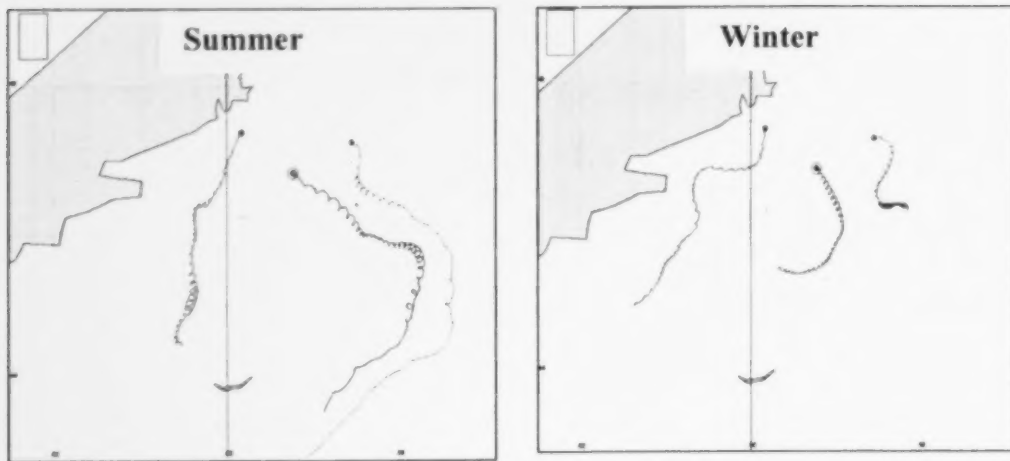


Figure 7-1: Modeled

Drift Trajectories at



the Surface by Season

Specific assessment of the potential risk to these sensitive shorelines should, however, be examined when the specific location and timing of an exploratory drilling project is known.

7.5.7 Species at Risk

The *Species at Risk Act* requires protection of species considered endangered, threatened, or of concern. The species of particular concern potentially occurring within the Misaine SEA area include the leatherback turtle and the blue whale. Sea turtles cross the Shelf to reach important feeding areas along the coast of Nova Scotia and in Sydney Bight. Blue whales migrate along the Shelf Edge, as well as the Laurentian Channel, to feed in the Gulf of St. Lawrence.

In terms of potential adverse impacts from oil and gas exploration, the Misaine SEA area does not pose risks different than many other parts of the Scotian Shelf or Slope where exploration is ongoing. However, a new seismic code of practice has been developed by DFO in consultation with relevant provincial and territorial governments and other federal departments (see Appendix A). This code of practice will further reduce the potential for impact on SARA designated species. Example requirements include:

- a qualified Marine Mammals Observer must check a safety zone of 500 m from the centre of the seismic source array for at least 30 minutes prior to start-up of the array;
- an array must be immediately shut down when an endangered or threatened marine mammal or sea turtle is observed within the safety zone, and
- at times of low visibility, passive acoustic monitoring, if a SARA listed vocalizing whale is reasonably expected in the area.

8 EFFECTS OF THE ENVIRONMENT ON POTENTIAL PROJECTS

The physical environment in the form of wind, waves and ice has a profound effect on the planning and execution of exploration activities in the offshore. Extreme weather and ice conditions may affect program scheduling for operations, including provision of supplies and services to offshore facilities.

Detailed analysis of weather and ice conditions is a routine part of project planning for exploration activities. Forecasts of weather and ice conditions are an important part of the selection of seismic, drilling and support equipment deployed. Meteorological and oceanographic monitoring programs are frequently part of offshore exploration activities. The collection of seismic information is particularly affected by weather, but this is more a data quality issue related to ambient noise levels than one of safety.

The short duration of exploration activities reduces concerns about earthquakes. Still, this issue should be examined in assessments of site-specific projects. Similarly, ice is not usually a major issue with respect to exploration activities on the eastern Scotian Shelf, but a specific project schedule may pose issues that need to be addressed. Operation at



times when freezing of salt spray may occur is an important safety issue that needs to be specifically addressed in the selection of equipment and timing of operations.

In relation to exploratory drilling, a hazards survey is conducted before the rig is placed at the well site, to ensure conditions are safe.

In terms of weather conditions, rigs and supply vessels are designed to withstand 1 in 100 year events. Rigs and vessels are required to be certified to withstand these kinds of events before they are allowed to operate in the area.

NEB et al. (1994) provides an overview of requirements for the operators of drilling or production installations related to environmental data. The primary objective of monitoring physical environmental data is to ensure safe and prudent conduct of operations, emergency response, and spill counter measures.

Climate change is affecting our ability to forecast extreme conditions, increasing the need for monitoring and research. The Misaine SEA area, however, is closer to shore, and thus safer than many areas currently open to oil and gas exploration. To some degree the land also offers protection from storms coming from the west. Thus, the Misaine SEA area does not pose unusual risk for oil and gas exploration. Still, climate change should be specifically considered in project specific environmental assessments to ensure unusual safety risks do not exist.

9 CUMULATIVE EFFECTS

The Cumulative Effects Assessment Practitioners Guide (Hegmann et al. 1999) defines cumulative effects as:

"changes to the environment that are caused by an action in combination with other past, present and future human actions."

A Cumulative Effects Assessment (CEA) is intended to assess the potential effects of a project in relation to other past, ongoing and reasonably foreseeable human activities and developments. The assessment typically enlarges the scale of an environmental impact assessment to a regional level, and considers a longer time interval than the assessment of project effects (Hegmann et al. 1999).

The assessment must consider other planned or reasonably foreseeable activities on the Scotian Shelf and Slope that might interact in a cumulative fashion with potential exploration activities within the Misaine SEA area. Table 9-1 provides the number of environmental assessments considered by the CNSOPB in fiscal years 2001 to 2004, as an indication of overall oil and gas industry activity.



Table 9-1: Number of Environmental Assessments Considered by the CNSOPB, 2001-2005

Activity	Seismic Surveys	Other Geophysical Surveys	Drilling Programs	Totals ¹
2004-2005	2	3	1	7
2003-2004	13	4	10	29
2002-2003	7	4	8	21
2001-2002	8	7	2	18

Note: ¹Totals include a small number of Strategic Environmental Assessments and other studies

As Table 9-1 indicates, oil and gas exploration activity has dropped over the last year, and expectations are that it may remain at a lower level of activity for the foreseeable future. Most oil and gas exploration and production to date has occurred on Sable Island Bank, with some exploration along the Slope Edge and near the Gully. The closest production platform to the Misaine SEA area is Venture, a distance of about 100 kilometres. Significant cumulative impacts in terms of noise or other aspects of exploration activity are unlikely over this distance. Cumulative impacts associated with drilling of the seven exploration wells already drilled within the Misaine SEA area is also unlikely because many years have passed since they were drilled.

Potential cumulative impacts are more probable along the Laurentian Channel where the Misaine SEA area abuts the Laurentian Channel lease area, or to the north where the Sydney Bight lease areas adjoin. However, a seismic survey is scheduled for Sydney Bight in the fall of 2005, many years before any activity can occur within the Misaine SEA area as a result of this assessment. Exploratory drilling, if it was to occur, would also likely be completed prior to any activity following from this SEA. Potential impact on blue whales, or other marine mammals, migrating along the Laurentian Channel into the Gulf of St. Lawrence is also a possibility. However, interest in the Nova Scotia portion of the Laurentian Channel area has been low, and the potential for future exploration in the area uncertain. In any case, these issues would be addressed in project specific environmental assessments required for these types of projects.

The most likely cumulative impacts within the Misaine SEA area on benthic communities and fish stocks will result from concurrent commercial fishing activities and oil and gas exploration. The cumulative impact of these effects is most likely additive and unlikely to significantly change the existing impact of commercial fisheries. It should be noted, however, that commercial fisheries in this part of the Scotian Shelf are considered to have relatively minor impacts on benthic habitat, and thus cumulative impacts on benthic habitat from exploratory drilling are also unlikely.

10 SUMMARY OF SPECIAL CONCERNS AND MITIGATING MEASURES

Analysis of potential impacts suggests that the Misaine SEA area is not more sensitive to the potential effects of oil and gas than other areas of the Scotian Shelf. It is, however, less affected by past human activities, particularly bottom trawling, than many other areas opened to exploration previously. The area also has uncommon topography and may support unusual benthic communities in the numerous deep holes of cold water.

Fisheries for snow crab and northern shrimp within the Misaine SEA area are highly lucrative. The Laurentian Channel, on the eastern edge of the area, is an important migration route for marine mammals. The endangered blue whale, which enters the Gulf of St. Lawrence to feed in the summer, is of particular concern. Also, numerous coastal sites along eastern Cape Breton are sensitive to potential accidental spills of hydrocarbons.

Lack of information on benthic habitat within the area and its relationship to seismic effects, particularly on shrimp, are a concern. Less scientific information has been gathered within the Misaine SEA area than most other areas where oil and gas exploration has occurred. To reflect this lack of information, and concern by commercial fishermen about the potential importance of the area to the sustainability of their fisheries, it is recommended that Louisbourg Hole be a priority area for the collection of additional baseline information. A review of its ecological importance should be conducted once sufficient new information is available. It is also recommended that, if well site surveys are to be conducted in the area, biological information be collected and made publicly available for incorporation into a baseline database.

New guidelines for seismic surveys have been developed by DFO, in conjunction with other agencies (http://www.dfo-mpo.gc.ca/canwaters-eauxcan/infocentre/media/seismic-sismique/intro_e.asp). These guidelines would be adopted for the Misaine SEA area, should it become open to exploration, and will ensure minimal impacts on marine mammals and species of concern listed under SARA.

Other mitigation measures considered in this assessment include:

- prohibition of selected or all exploration activities in selected areas;
- baseline studies or effects monitoring;
- modified rules for seismic operations dealing with ramping up, response to sightings, or night time operations;
- use of specially trained observers to deal with specific issues, and
- zero discharge from exploratory drilling operations.



These additional mitigation measures can be applied broadly to exploration activities within the Misaine SEA area. They address the specific sensitivities identified in this SEA, and conform to the guidance provided in ESSIM. They will work to ensure that the residual impacts from oil and gas exploration remain at acceptably low levels. Additional mitigation, particularly with reference to the timing of activities to avoid especially sensitive periods are addressed in project-specific environmental assessments that may follow this SEA should a call for bids be issued.

The Misaine SEA area is less affected by past human activities, particularly bottom trawling, than other areas opened to exploration previously, and likely supports productive and possibly uncommon benthic communities. Nonetheless, with appropriate mitigation in place, no reason could be found to exclude exploration for oil and gas from the area.

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Glossary

μPa	Micropascal (unit of pressure), usually referenced at 1 m from the sound source
2D	2 Dimensional (of seismic)
3D	3 Dimensional (of seismic)
Acute	Of relatively short duration
Barite	Barium sulphate- a naturally occurring heavy mineral added to drilling mud as a weighting agent to increase its specific gravity, and thus the hydrostatic head of the mud column
Benthic	Relating to organisms living in or on the seabed
Bentonite	Naturally occurring clay mineral; used in drilling fluids to increase viscosity
Bioaccumulation	The uptake of elements or compounds within organisms
Biodiversity	Diversity of species
Biomass	Living material; e.g. The total mass of a species or of all living organisms present in a habitat; usually excluding shell mass
Bongo net	A round cannister (resembling a bongo drum) with a net at one end used to sample plankton
Cetaceans	Aquatic mammals including whales, dolphins and porpoises
cm	Centimeters
Condensate	Liquid hydrocarbons, sometimes produced along with natural gas
Contaminants	Substances which may cause impurity or pollution
Copepod	small crustaceans, usually planktonic
Cuttings pile	Pile of mainly rock chips deposited on the seabed as a result of drilling
dB	Decibel, a log-based unit of pressure - 6 dB represents a doubling of the intensity
Demersal	Living at or near the bottom of the sea
Drill cuttings	Rock chips produced as a result of drilling

Drilling mud	Mixture of clays, water and chemicals used to cool and lubricate the drill bit, return rock cuttings to the surface and to exert hydrostatic pressure to maintain well control
ENGO	Environmental Non-Governmental Organization
Environmental Effect	Any change to the environment of its use
Environmental Impact Assessment	Systematic review of the environmental effects a proposed project may have on the surrounding environment
Epifauna	Organisms living on the surface of the seabed
Epipelagic	Relating to towards the surface of the water column
Exploration well	Well drilled to determine whether hydrocarbons are present in a particular area
Flare	Controlled burning of gas for pressure relief (or during well testing for disposal of excess gas)
Fugitive emissions	Very small chronic escape of gas and liquids from the equipment and pipe work
g	Grams (weight measurement)
Gadoid	Fish of the cod family
Greenhouse effect	Rise in the Earth's temperature due to infra-red radiation being trapped in the atmosphere by water vapour, carbon dioxide and other gases
Greenhouse gas	Gas which contributes to the Greenhouse effect; includes gases such as carbon dioxide and methane
Hydrocarbon	Compounds containing only the elements carbon and hydrogen, including oil and natural gas
Hz	Hertz (unit of frequency)
km	Kilometers
m	Meters
Macrofauna	Larger benthic fauna, defined as >0.5mm or 1.0 mm in size
Macroinvertebrate	Larger, free-floating animals in plankton that can be seen by the naked eye



mg	Milligrams
Neuston	The surface of the ocean
Organic Compounds	Materials containing carbon combined with hydrogen, often with other elements
Pelagic	Organisms living in the water column of the sea
Phytoplankton	Free-floating microscopic plants (algae) including diatoms and dinoflagellates
Plankton	Free-floating microscopic organisms
ppm	Parts per million
Produced water	Water removed from the reservoir along with oil and natural gas
ROV	Remote Operated Vehicle, a small, unmanned submersible used to collect video, photographs and samples from the deep sea
SBM	Synthetic oil-Based Mud
SEA	Strategic Environmental Assessment or Appraisal
Seismic	Surveying technique used to determine the structure of the underlying rocks by passing acoustic shock waves into the strata and detecting and measuring the reflected signals. Depending on the spacing of the survey lines, data processing method and temporal elements, the seismic is referred to as either 2-D, 3-D or 4-D.
Shallow gas	Gas accumulation present near the surface of the seabed
Sidescan Sonar	Side-looking sonar system used to map seabed features
Spud	Installation of conductor; the date of commencement of a drilling operation
Thermocline	Stable boundary between two layers of water of different temperatures
Venting	Release of gas to atmosphere for operational or emergency reasons
Zooplankton	Free-floating animals, often microscopic



APPENDIX A

ADDITIONAL INFORMATION FOR THE ENVIRONMENTAL SETTING

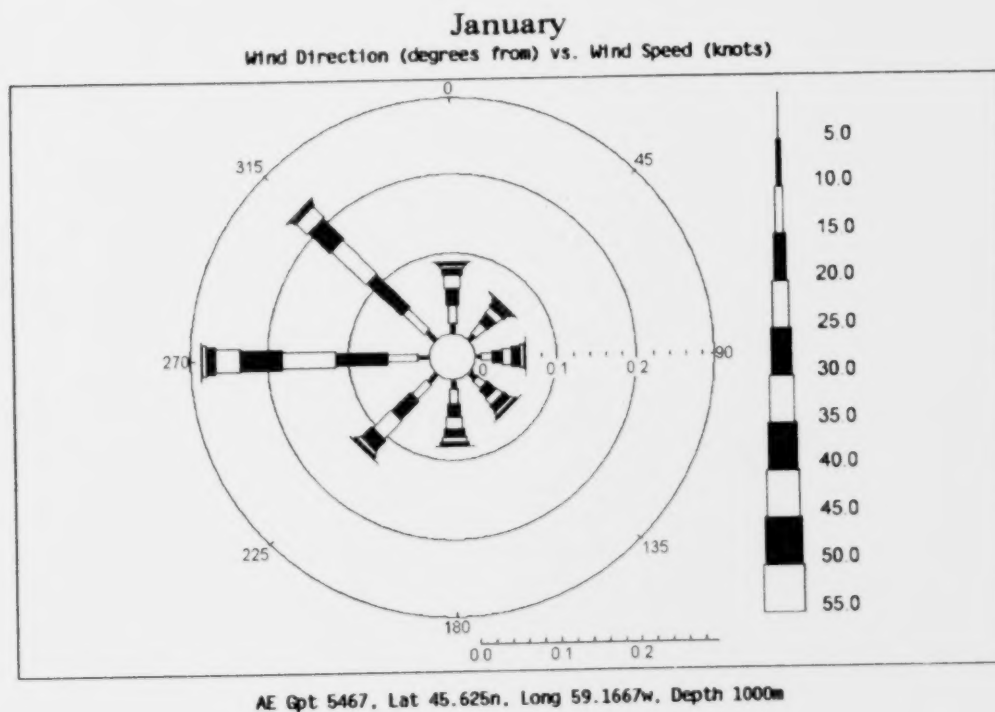


Figure A-1: January Wind Direction vs. Wind Speed

Table A-1

January Percentage Frequency Occurrence of Wind Speed by Direction

Source: AES40 Grid Point 5467 (45.6250N, 59.1667W) 1954 - 2003

	Wind Direction (blowing <u>from</u>)								Total
	NE	E	SE	S	SW	W	NW	N	
0 - <5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.6
5 - <10	0.7	0.5	0.8	0.9	1.3	1.4	1.5	1.2	8.2
10 - <15	1.7	1.4	1.3	1.8	2.6	3.8	3.7	2.3	18.5
15 - <20	1.3	1.2	1.4	1.7	3.2	6.4	5.8	2.1	23.3
20 - <25	0.9	1.1	1.0	1.4	3.2	6.7	6.0	1.7	22.0
25 - <30	0.7	1.0	0.9	1.1	1.8	5.1	3.6	0.8	15.0
30 - <35	0.3	0.5	0.5	0.6	0.5	3.0	2.0	0.5	7.9
35 - <40	0.2	0.1	0.3	0.4	0.4	1.2	0.5	0.2	3.3
40 - <45	0.0	0.1	0.1	0.1	0.0	0.5	0.3	0.1	1.1
45 - <50	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1
50 - <55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	5.9	5.9	6.4	8.2	13.0	28.2	23.4	8.9	100.0

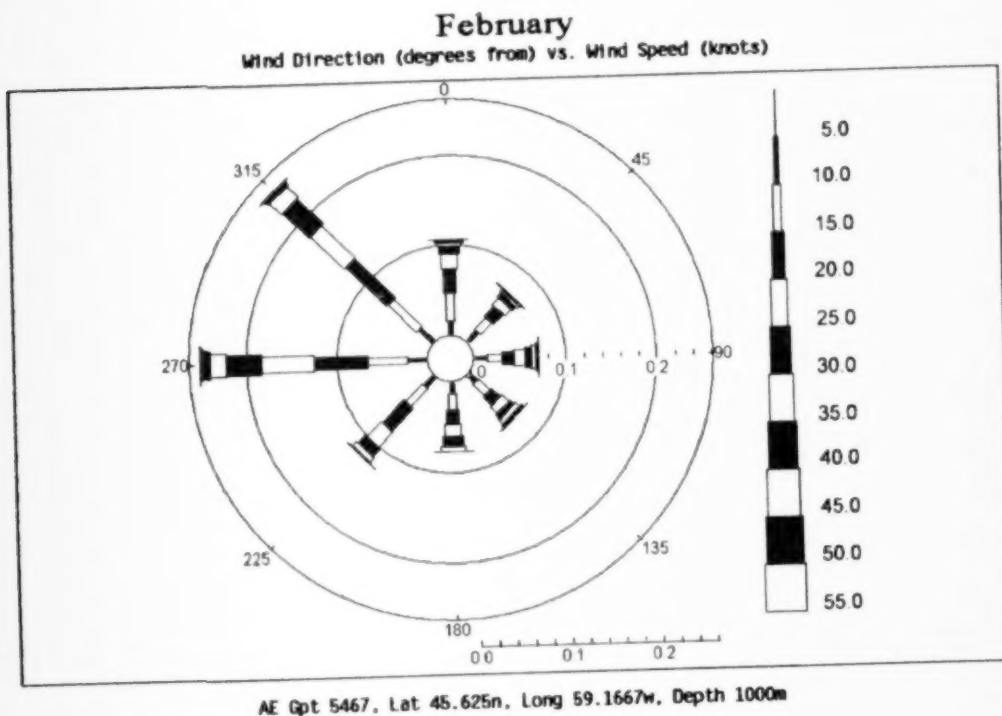


Figure A-2: February Wind Direction vs. Wind Speed

Table A-2

February Percentage Frequency Occurrence of Wind Speed by Direction

Source: AES40 Grid Point 5467 (45.6250N, 59.1667W) 1954 - 2003

	Wind Direction (blowing from)								Total
	NE	E	SE	S	SW	W	NW	N	
0 - <5	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.1	1.1
5 - <10	1.4	1.2	0.9	1.1	1.4	1.9	2.0	1.4	11.3
10 - <15	1.8	1.6	1.7	1.8	2.7	4.5	4.4	3.1	21.5
15 - <20	1.5	1.3	1.3	1.7	3.4	5.9	6.3	2.6	24.0
20 - <25	1.0	1.2	1.0	1.3	2.3	5.8	5.2	1.7	19.5
25 - <30	0.6	0.8	0.7	1.1	1.2	3.9	4.0	0.9	13.0
30 - <35	0.3	0.5	0.6	0.5	0.6	1.8	1.8	0.4	6.5
35 - <40	0.1	0.3	0.4	0.0	0.1	0.7	0.5	0.2	2.3
40 - <45	0.1	0.0	0.0	0.0	0.0	0.2	0.1	0.1	0.6
45 - <50	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.2
50 - <55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	6.9	6.9	6.8	7.6	11.9	25.0	24.4	10.6	100.0

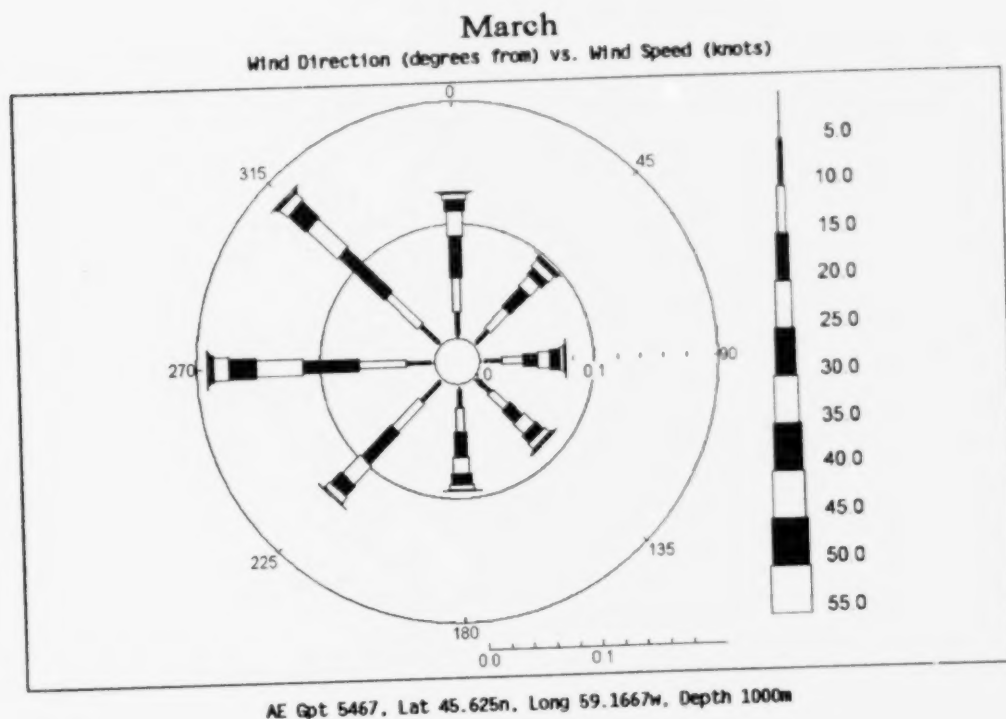


Figure A-3: March Wind Direction vs. Wind Speed

Table A-3

March Percentage Frequency Occurrence of Wind Speed by Direction
Source: AES40 Grid Point 5467 (45.6250N, 59.1667W) 1954 - 2003

	Wind Direction (blowing from)								Total
	NE	E	SE	S	SW	W	NW	N	
0 - <5	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.2	2.4
5 - <10	1.5	1.5	1.5	1.7	2.4	2.1	2.1	2.1	14.9
10 - <15	2.4	1.8	1.9	2.1	3.4	4.1	3.9	3.0	22.5
15 - <20	2.3	1.3	1.6	2.2	3.7	4.9	5.5	3.6	25.1
20 - <25	1.2	1.1	1.3	1.4	2.3	4.1	3.6	2.2	17.2
25 - <30	0.7	0.8	0.9	1.0	1.3	2.4	2.1	0.9	10.1
30 - <35	0.8	0.4	0.6	0.4	0.6	1.3	0.9	0.5	5.6
35 - <40	0.4	0.1	0.2	0.1	0.1	0.4	0.2	0.1	1.5
40 - <45	0.1	0.0	0.1	0.0	0.1	0.1	0.2	0.2	0.7
45 - <50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
50 - <55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	9.6	7.4	8.3	9.2	14.0	19.9	18.8	12.9	100.0

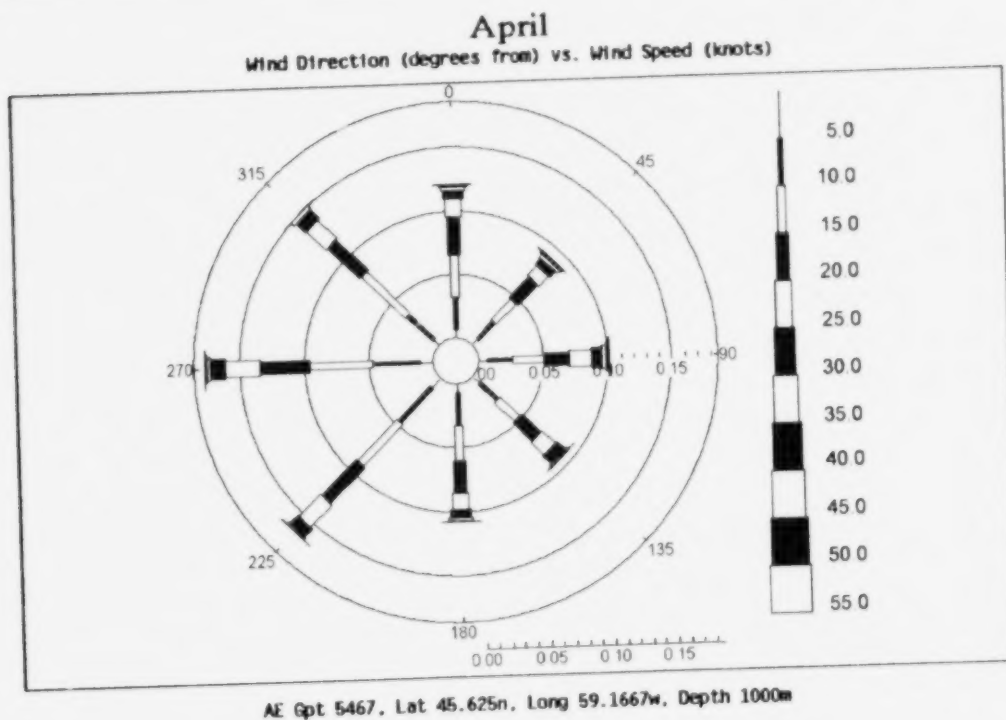


Figure A-4: April Wind Direction vs. Wind Speed

Table A-4

April Percentage Frequency Occurrence of Wind Speed by Direction
Source: AES40 Grid Point 5467 (45.6250N, 59.1667W) 1954 - 2003

	Wind Direction (blowing from)								Total
	NE	E	SE	S	SW	W	NW	N	
0 - <5	0.5	0.5	0.6	0.6	1.0	1.0	0.6	0.6	5.4
5 - <10	1.9	2.0	1.9	2.6	3.7	3.7	2.8	2.6	21.1
10 - <15	2.2	2.4	2.2	2.8	4.5	4.9	4.7	3.3	27.0
15 - <20	2.2	2.0	2.0	2.6	3.9	3.8	3.5	3.0	23.0
20 - <25	1.1	1.7	1.4	1.2	2.4	2.7	2.1	1.4	14.0
25 - <30	0.6	0.8	0.8	0.6	0.9	1.2	1.0	0.6	6.5
30 - <35	0.3	0.3	0.2	0.3	0.2	0.3	0.3	0.3	2.2
35 - <40	0.2	0.2	0.1	0.0	0.0	0.1	0.0	0.1	0.8
40 - <45	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1
45 - <50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50 - <55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	9.0	10.0	9.2	10.7	16.4	17.7	15.0	12.0	100.0

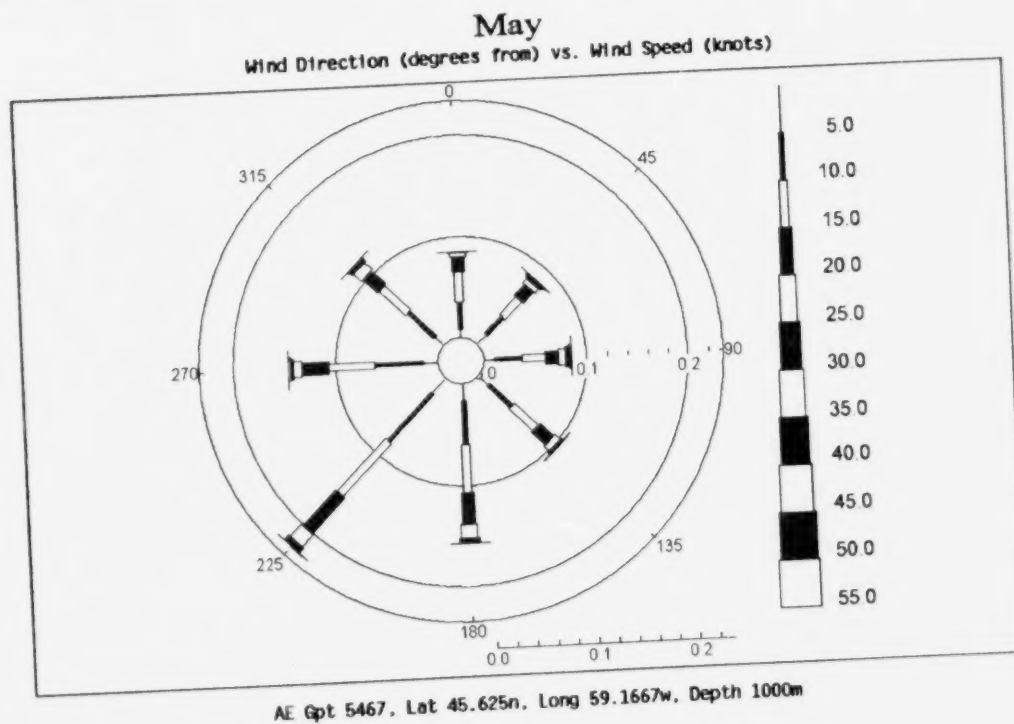


Figure A-5: May Wind Direction vs. Wind Speed

Table A-5

May Percentage Frequency Occurrence of Wind Speed by Direction
Source: AES40 Grid Point 5467 (45.6250N, 59.1667W) 1954 - 2003

	Wind Direction (blowing from)								Total
	NE	E	SE	S	SW	W	NW	N	
0 - <5	1.2	0.9	1.1	1.6	1.9	1.5	1.2	0.8	10.2
5 - <10	2.3	2.7	3.2	4.2	6.3	4.7	3.5	2.7	29.6
10 - <15	2.4	2.3	3.2	4.8	7.0	4.6	3.6	3.0	30.9
15 - <20	1.5	1.3	1.8	3.1	4.7	2.7	1.9	1.5	18.5
20 - <25	0.5	0.7	0.7	1.4	1.7	0.7	1.0	0.4	7.2
25 - <30	0.3	0.4	0.3	0.4	0.5	0.4	0.4	0.1	2.7
30 - <35	0.2	0.1	0.1	0.1	0.1	0.2	0.1	0.0	0.8
35 - <40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
40 - <45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45 - <50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50 - <55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	8.4	8.4	10.3	15.7	22.3	14.7	11.8	8.5	100.0

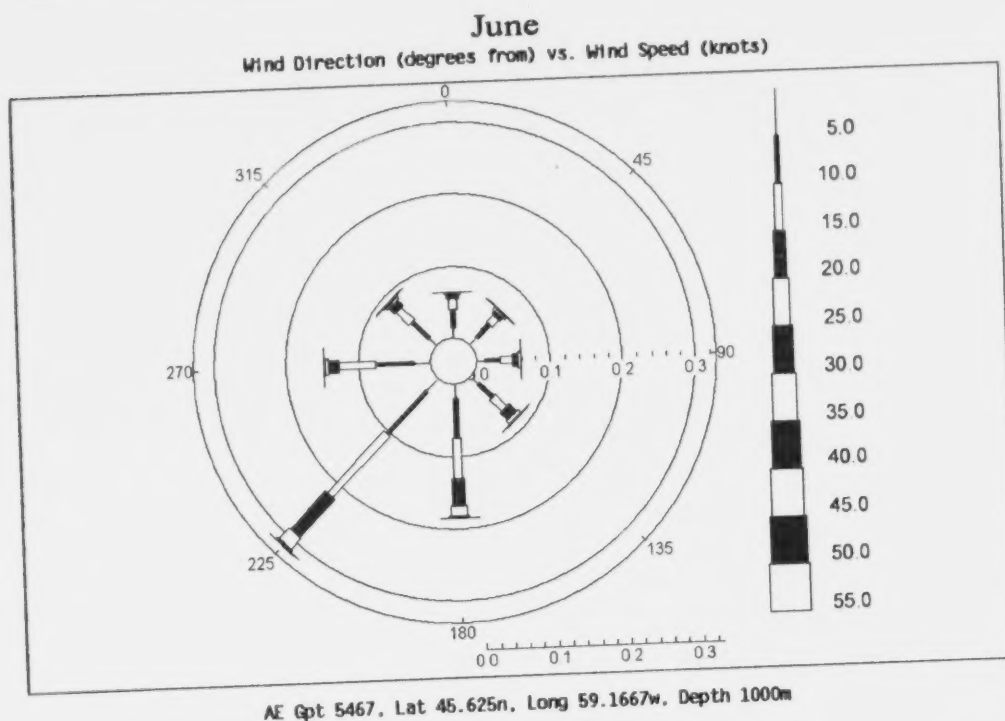


Figure A-6: June Wind Direction vs. Wind Speed

Table A-6

June Percentage Frequency Occurrence of Wind Speed by Direction
Source: AES40 Grid Point 5467 (45.6250N, 59.1667W) 1954 - 2003

	Wind Direction (blowing from)								Total
	NE	E	SE	S	SW	W	NW	N	
0 - <5	1.2	1.0	1.2	1.8	2.2	2.3	1.4	1.4	12.4
5 - <10	2.6	2.1	2.7	5.5	8.1	5.4	3.3	2.6	32.2
10 - <15	1.3	1.7	2.3	5.7	11.6	5.0	2.5	1.6	31.5
15 - <20	0.6	0.7	1.5	3.8	7.1	1.6	1.1	0.5	16.8
20 - <25	0.3	0.4	0.5	1.4	2.1	0.5	0.4	0.1	5.7
25 - <30	0.1	0.1	0.1	0.3	0.3	0.1	0.1	0.1	1.3
30 - <35	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.2
35 - <40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40 - <45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45 - <50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50 - <55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	6.1	5.9	8.3	18.4	31.4	14.7	9.0	6.3	100.0

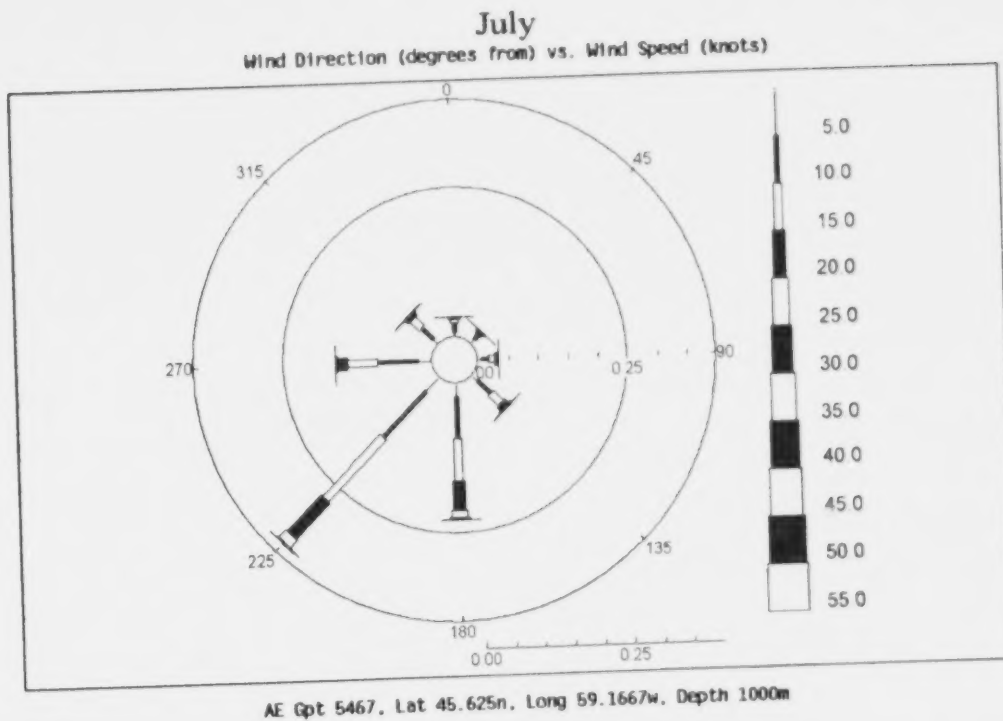


Figure A-7: July Wind Direction vs. Wind Speed

Table A-7

July Percentage Frequency Occurrence of Wind Speed by Direction
Source: AES40 Grid Point 5467 (45.6250N, 59.1667W) 1954 - 2003

	Wind Direction (blowing from)								Total
	NE	E	SE	S	SW	W	NW	N	
0 - <5	0.6	0.5	1.1	2.3	3.1	2.3	1.2	0.7	11.8
5 - <10	1.1	1.1	3.1	6.9	10.5	6.6	2.6	1.5	33.3
10 - <15	0.4	1.1	2.4	7.1	14.2	5.1	2.2	0.7	33.2
15 - <20	0.2	0.5	0.8	4.8	8.2	1.7	0.5	0.3	17.0
20 - <25	0.1	0.1	0.2	1.2	1.8	0.2	0.2	0.1	3.9
25 - <30	0.0	0.0	0.1	0.3	0.2	0.1	0.1	0.1	0.8
30 - <35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
35 - <40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40 - <45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45 - <50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50 - <55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	2.4	3.3	7.7	22.6	37.9	16.0	6.8	3.3	100.0

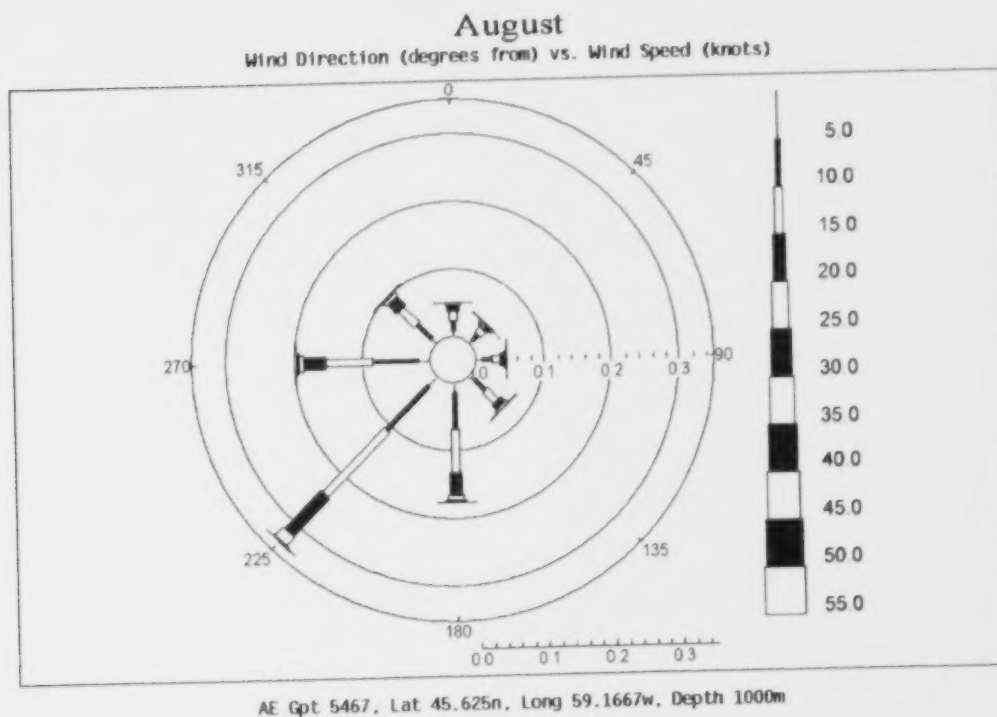


Figure A-8: August Wind Direction vs. Wind Speed

Table A-8

August Percentage Frequency Occurrence of Wind Speed by Direction

Source: AES40 Grid Point 5467 (45.6250N, 59.1667W) 1954 - 2003

	Wind Direction (blowing from)								Total
	NE	E	SE	S	SW	W	NW	N	
0 - <5	0.4	0.7	0.6	1.4	1.8	1.7	0.9	0.7	8.1
5 - <10	1.1	1.5	2.3	5.3	8.9	6.7	3.1	1.6	30.6
10 - <15	1.1	1.1	2.4	6.5	13.2	7.0	3.3	1.5	36.1
15 - <20	0.4	0.7	0.9	3.3	7.6	3.1	1.8	0.9	18.7
20 - <25	0.3	0.2	0.4	0.7	1.7	0.8	0.6	0.3	5.0
25 - <30	0.1	0.1	0.0	0.3	0.2	0.4	0.2	0.1	1.3
30 - <35	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2
35 - <40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40 - <45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45 - <50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50 - <55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	3.5	4.3	6.6	17.5	33.5	19.7	9.9	5.0	100.0

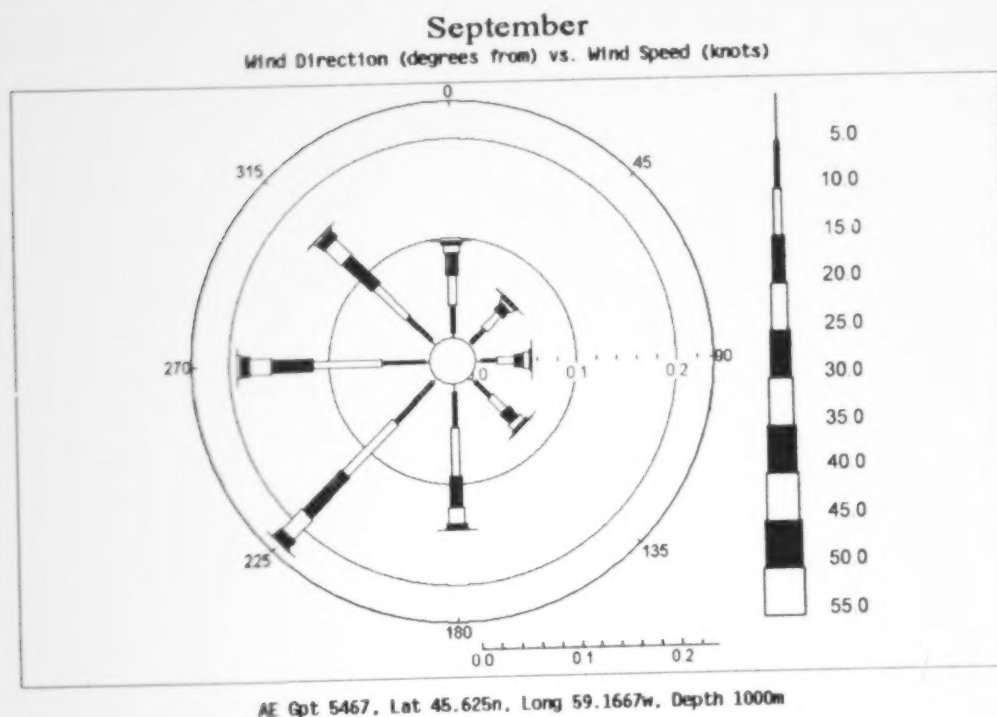


Figure A-9: September Wind Direction vs. Wind Speed

Table A-9

September Percentage Frequency Occurrence of Wind Speed by Direction

Source: AES40 Grid Point 5467 (45.6250N, 59.1667W) 1954 - 2003

	Wind Direction (blowing from)								Total
	NE	E	SE	S	SW	W	NW	N	
0 - <5	0.2	0.4	0.5	0.7	0.5	0.4	0.6	0.5	3.9
5 - <10	1.9	1.6	2.2	3.5	5.5	4.3	3.4	2.7	25.0
10 - <15	2.1	1.8	2.0	4.8	7.1	6.8	4.4	2.9	32.0
15 - <20	0.9	0.9	1.4	3.2	5.5	4.2	4.0	2.2	22.3
20 - <25	0.4	0.5	0.7	1.7	2.8	2.2	2.3	0.9	11.4
25 - <30	0.2	0.2	0.2	0.4	1.0	0.9	1.0	0.3	4.2
30 - <35	0.1	0.1	0.1	0.1	0.1	0.3	0.3	0.1	1.0
35 - <40	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.2
40 - <45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45 - <50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50 - <55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	5.8	5.4	7.0	14.4	22.6	19.2	15.9	9.6	100.0

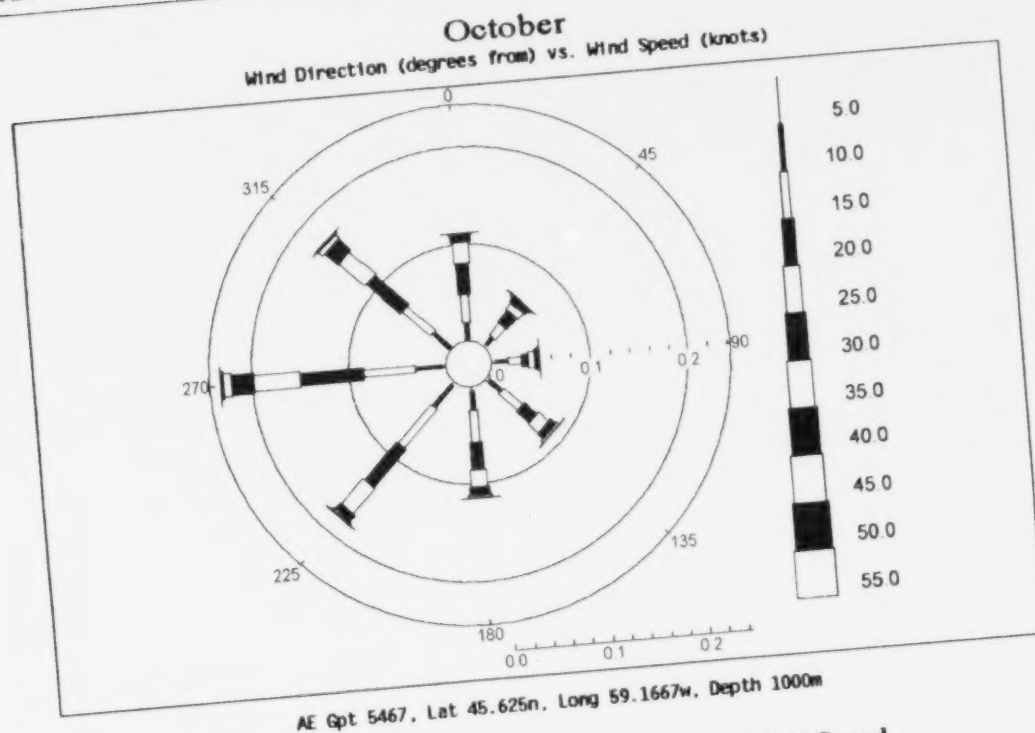


Figure A-10: October Wind Direction vs. Wind Speed

Table A-10

October Percentage Frequency Occurrence of Wind Speed by Direction
Source: AES40 Grid Point 5467 (45.6250N, 59.1667W) 1954 - 2003

Wind Speed (knots)	Wind Direction (blowing from)								N	Total
	NE	E	SE	S	SW	W	NW			
0 - <5	0.2	0.2	0.4	0.3	0.3	0.3	0.2	0.2	0.2	2.0
5 - <10	1.0	1.3	1.5	2.0	3.0	2.9	2.3	1.7	15.6	
10 - <15	1.6	1.4	2.5	3.3	5.2	5.3	3.9	2.9	26.0	
15 - <20	1.5	0.7	1.7	2.9	5.1	6.5	4.6	3.2	26.4	
20 - <25	0.8	0.7	1.4	1.7	3.4	4.7	3.6	2.2	18.4	
25 - <30	0.4	0.3	0.7	0.8	0.8	2.3	1.8	0.8	8.0	
30 - <35	0.1	0.2	0.3	0.3	0.2	0.8	0.6	0.1	2.5	
35 - <40	0.1	0.0	0.1	0.0	0.1	0.3	0.2	0.1	0.9	
40 - <45	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	
45 - <50	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	
50 - <55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Total	5.9	4.7	8.6	11.3	18.1	23.3	17.1	11.1	100.0	

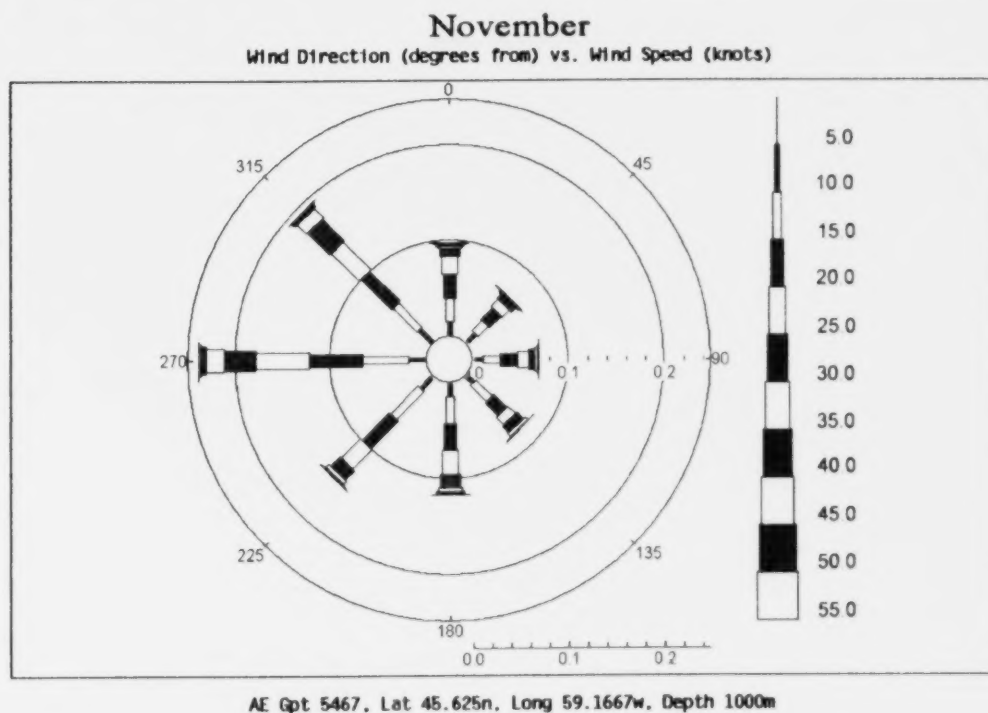


Figure A-11: November Wind Direction vs. Wind Speed

Table A-11

November Percentage Frequency Occurrence of Wind Speed by Direction

Source: AES40 Grid Point 5467 (45.6250N, 59.1667W) 1954 - 2003

	Wind Direction (blowing from)								Total
	NE	E	SE	S	SW	W	NW	N	
0 - <5	0.1	0.2	0.2	0.1	0.2	0.1	0.1	0.0	1.0
5 - <10	1.1	0.9	0.8	1.3	1.6	1.8	2.0	1.5	10.9
10 - <15	1.5	1.8	2.3	2.8	4.2	4.8	3.5	2.4	23.3
15 - <20	1.7	1.8	2.0	2.8	4.0	5.5	4.4	2.6	24.7
20 - <25	1.1	1.2	1.1	2.5	2.8	5.6	4.1	1.9	20.3
25 - <30	0.6	0.6	0.9	1.4	1.3	3.3	3.3	0.8	12.2
30 - <35	0.1	0.3	0.4	0.5	0.5	1.9	1.4	0.3	5.4
35 - <40	0.1	0.1	0.1	0.2	0.2	0.6	0.4	0.2	1.8
40 - <45	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.5
45 - <50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
50 - <55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	6.4	6.8	7.8	11.6	14.7	23.6	19.3	9.7	100.0

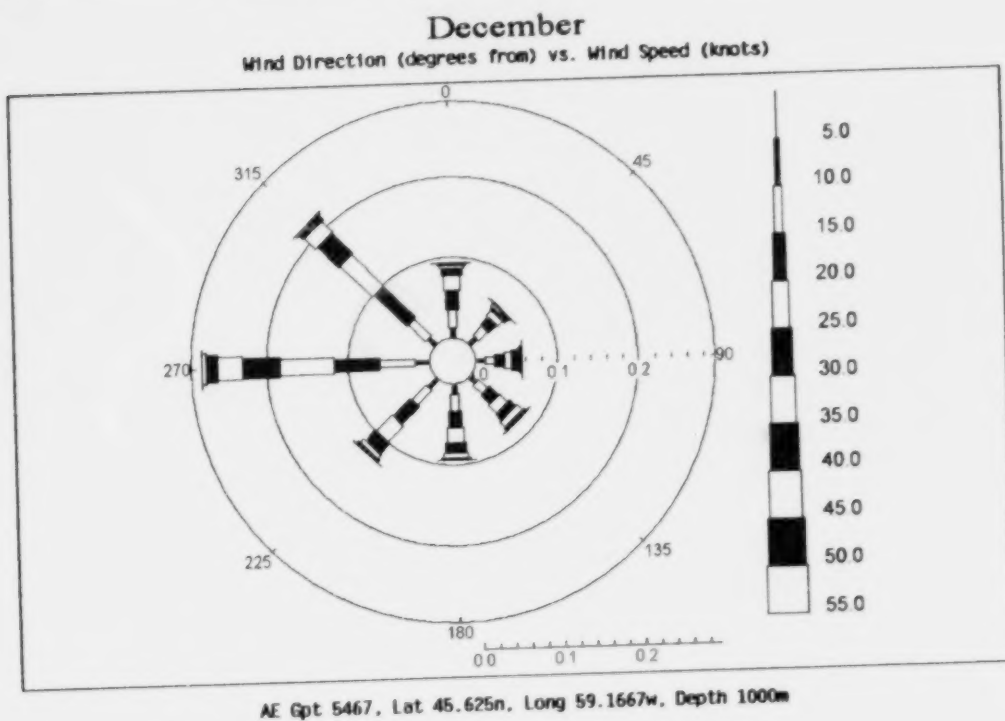


Figure A-12: December Wind Direction vs. Wind Speed

Table A-12

December Percentage Frequency Occurrence of Wind Speed by Direction
Source: AES40 Grid Point 5467 (45.6250N, 59.1667W) 1954 - 2003

	Wind Direction (blowing <u>from</u>)								Total
	NE	E	SE	S	SW	W	NW	N	
0 - <5	0.0	0.1	0.0	0.1	0.0	0.1	0.1	0.0	0.4
5 - <10	1.0	0.9	0.8	1.1	1.4	1.7	1.2	1.2	9.3
10 - <15	1.6	1.1	1.6	2.1	2.6	4.4	3.0	2.2	18.6
15 - <20	1.3	1.3	1.5	2.1	3.0	5.7	5.6	2.4	22.9
20 - <25	0.9	0.9	1.4	1.8	2.8	6.6	5.6	1.9	21.8
25 - <30	0.5	0.7	1.1	1.4	1.7	4.6	3.6	0.9	14.5
30 - <35	0.3	0.4	1.0	0.5	0.6	3.1	1.9	0.4	8.3
35 - <40	0.1	0.1	0.4	0.3	0.3	1.4	0.7	0.1	3.4
40 - <45	0.0	0.1	0.1	0.0	0.1	0.4	0.2	0.1	1.0
45 - <50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
50 - <55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	5.7	5.5	7.8	9.3	12.6	28.1	21.9	9.3	100.0

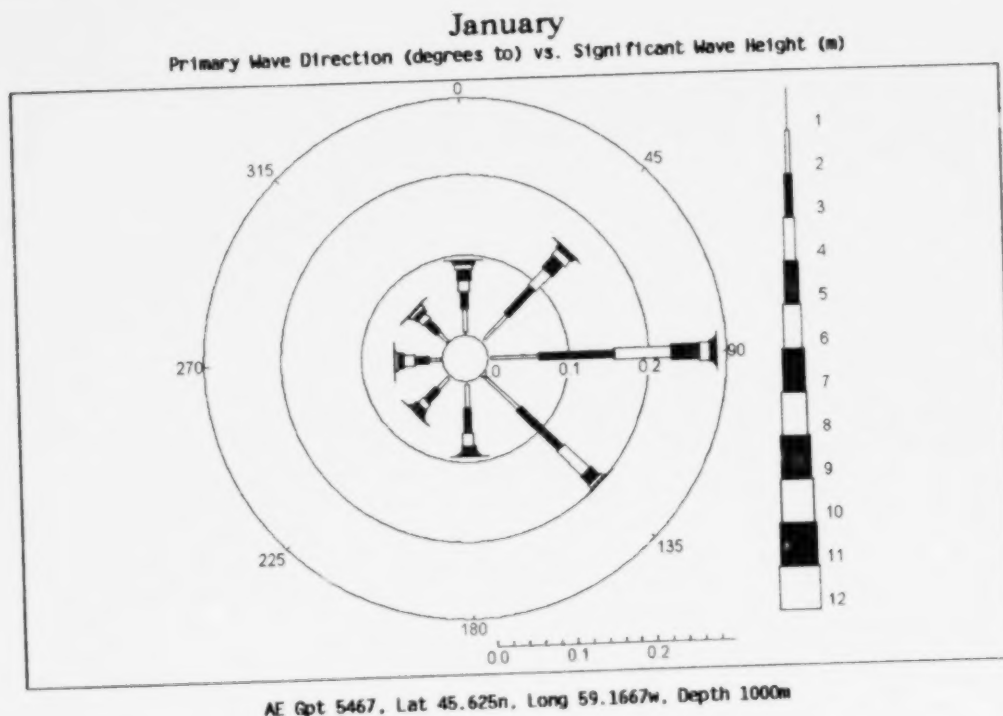


Figure A-13: January Wave Direction vs. Wave Height

Table A-13

January Percentage Frequency Occurrence of Wave Height by Direction
Source: AES40 Grid Point 5467 (45.6250N, 59.1667W) 1954 - 2003

		Wave Direction (travelling <u>to</u>)								
		NE	E	SE	S	SW	W	NW	N	Total
Significant Wave Height (metres)	0.0 - <1.0	0.5	0.3	0.3	0.3	0.3	0.2	0.2	0.4	2.3
	1.0 - <2.0	4.0	5.9	5.8	2.9	2.0	1.5	1.6	2.9	26.5
	2.0 - <3.0	4.6	9.4	7.2	3.1	2.0	1.8	2.0	2.1	32.2
	3.0 - <4.0	2.7	7.0	4.3	1.7	1.0	1.4	0.9	1.5	20.5
	4.0 - <5.0	2.0	3.6	1.5	0.7	0.6	0.6	0.6	1.3	10.8
	5.0 - <6.0	1.1	1.2	0.6	0.3	0.3	0.4	0.4	0.7	4.8
	6.0 - <7.0	0.4	0.5	0.1	0.2	0.2	0.2	0.2	0.4	2.1
	7.0 - <8.0	0.1	0.3	0.1	0.1	0.0	0.0	0.0	0.1	0.6
	8.0 - <9.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.3
	9.0 - <10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	10.0 - <11.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	11.0 - <12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total		15.5	28.2	19.8	9.2	6.3	6.0	5.9	9.3	100.0

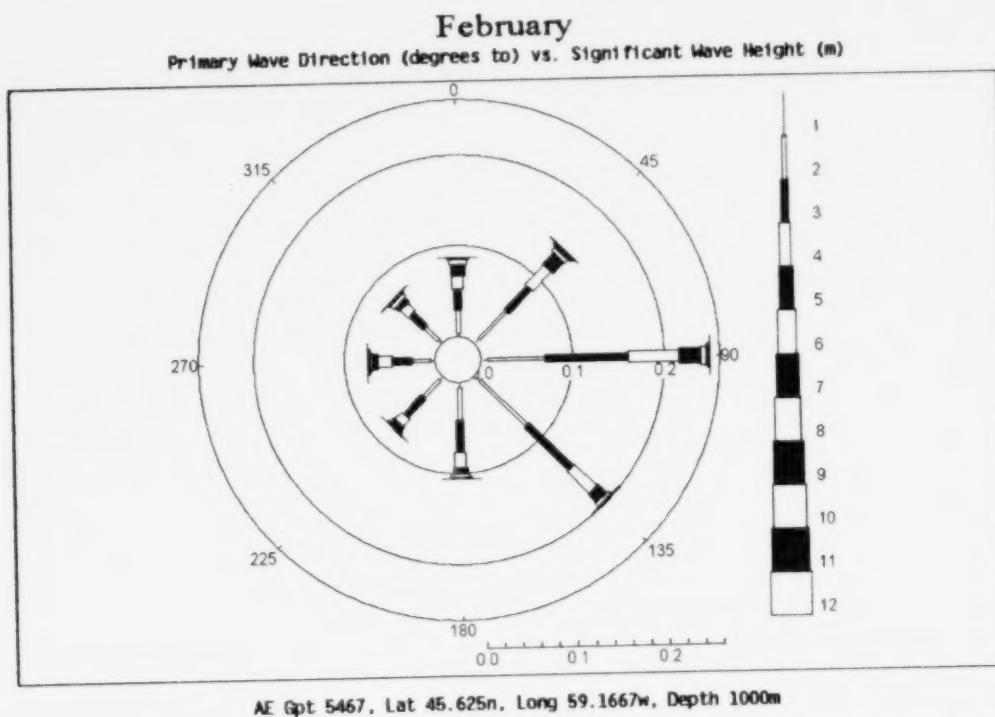


Figure A-14: February Wave Direction vs. Wave Height

Table A-14

February Percentage Frequency Occurrence of Wave Height by Direction
Source: AES40 Grid Point 5467 (45.6250N, 59.1667W) 1954 - 2003

	Wave Direction (travelling <u>to</u>)								Total
	NE	E	SE	S	SW	W	NW	N	
0.0 - <1.0	0.6	0.6	0.6	0.4	0.4	0.4	0.4	0.3	3.7
1.0 - <2.0	4.3	6.3	7.1	3.6	2.6	2.2	2.2	2.5	30.8
2.0 - <3.0	3.6	9.1	6.8	3.6	2.8	2.2	2.1	2.3	32.4
3.0 - <4.0	2.9	5.6	3.4	1.7	1.1	1.5	1.2	1.4	18.7
4.0 - <5.0	1.8	2.4	1.3	0.6	0.6	0.7	0.6	1.2	9.2
5.0 - <6.0	0.5	0.6	0.4	0.4	0.2	0.2	0.5	0.6	3.4
6.0 - <7.0	0.2	0.3	0.1	0.2	0.1	0.1	0.1	0.1	1.1
7.0 - <8.0	0.2	0.1	0.0	0.0	0.1	0.1	0.1	0.0	0.6
8.0 - <9.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1
9.0 - <10.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
10.0 - <11.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.0 - <12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	14.1	24.9	19.7	10.4	7.8	7.4	7.2	8.6	100.0

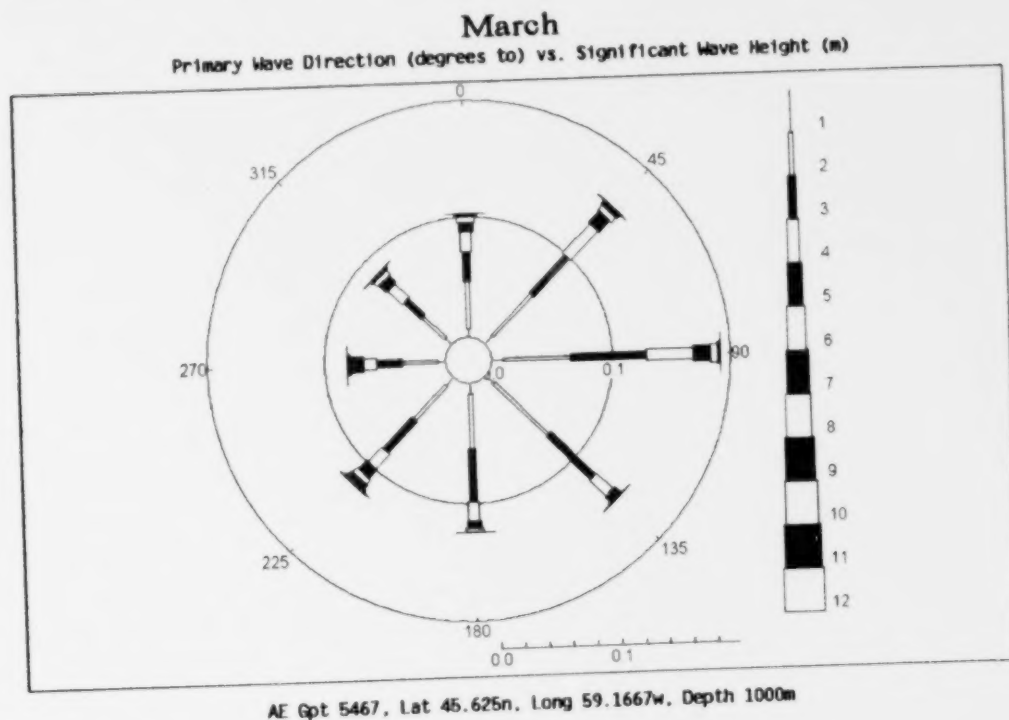


Figure A-15: March Wave Direction vs. Wave Height

Table A-15

March Percentage Frequency Occurrence of Wave Height by Direction

Source: AES40 Grid Point 5467 (45.6250N, 59.1667W) 1954 - 2003

Significant Wave Height (metres)	Wave Direction (travelling to)								Total
	NE	E	SE	S	SW	W	NW	N	
0.0 - <1.0	0.8	0.8	0.7	0.8	0.8	0.7	0.8	0.6	6.0
1.0 - <2.0	4.7	5.6	6.2	4.6	3.9	2.9	2.6	4.0	34.6
2.0 - <3.0	4.3	6.3	5.2	4.3	3.5	2.1	2.0	2.4	30.0
3.0 - <4.0	3.4	3.9	1.9	1.6	1.6	1.1	1.6	1.7	16.8
4.0 - <5.0	1.3	1.4	0.6	0.6	0.9	1.0	0.9	0.7	7.4
5.0 - <6.0	0.5	0.5	0.1	0.3	0.5	0.2	0.5	0.5	3.1
6.0 - <7.0	0.4	0.2	0.1	0.0	0.4	0.2	0.2	0.2	1.6
7.0 - <8.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.1	0.3
8.0 - <9.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.2
9.0 - <10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.0 - <11.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.0 - <12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	15.4	18.8	14.8	12.2	12.0	8.1	8.5	10.3	100.0

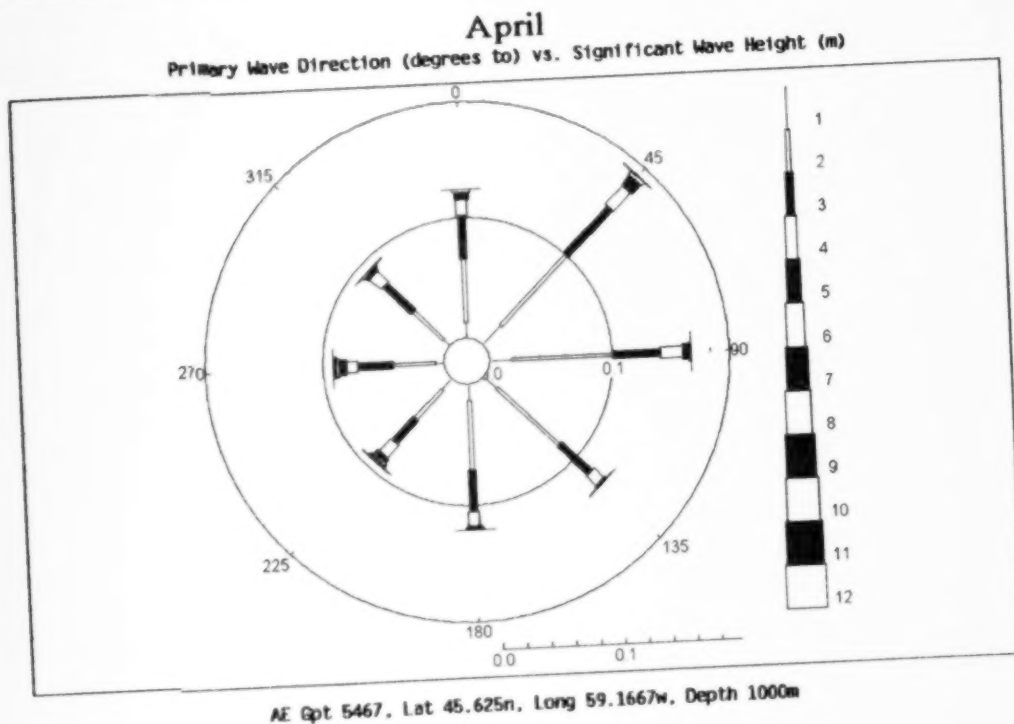


Figure A-16: April Wave Direction vs. Wave Height

Table A-16

April Percentage Frequency Occurrence of Wave Height by Direction
Source: AES40 Grid Point 5467 (45.6250N, 59.1667W) 1954 - 2003

	Wave Direction (travelling to)								Total
	NE	E	SE	S	SW	W	NW	N	
0.0 - <1.0	2.1	1.6	1.3	1.2	1.2	0.7	0.7	1.2	10.0
1.0 - <2.0	7.9	8.3	6.9	5.8	3.3	3.5	3.5	5.3	44.4
2.0 - <3.0	5.3	4.0	3.4	3.5	2.6	2.9	3.2	3.6	28.4
3.0 - <4.0	2.1	1.8	1.1	1.1	1.4	1.0	1.3	1.4	11.2
4.0 - <5.0	1.1	0.5	0.2	0.2	0.4	0.6	0.3	0.5	3.8
5.0 - <6.0	0.3	0.2	0.0	0.1	0.2	0.2	0.2	0.2	1.4
6.0 - <7.0	0.1	0.0	0.0	0.0	0.2	0.2	0.1	0.0	0.6
7.0 - <8.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1
8.0 - <9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9.0 - <10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.0 - <11.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.0 - <12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	18.8	16.5	13.0	11.9	9.3	9.2	9.2	12.3	100.0

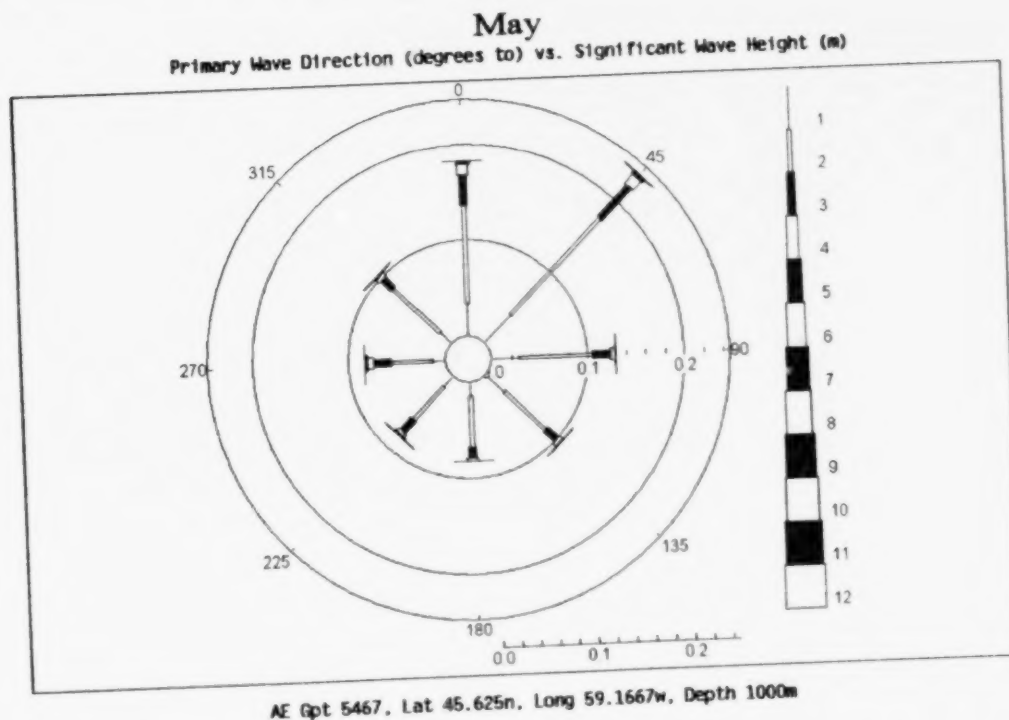


Figure A-17: May Wave Direction vs. Wave Height

Table A-17

May Percentage Frequency Occurrence of Wave Height by Direction
Source: AES40 Grid Point 5467 (45.6250N, 59.1667W) 1954 - 2003

Significant Wave Height (metres)	Wave Direction (travelling to)								Total
	NE	E	SE	S	SW	W	NW	N	
0.0 - <1.0	3.8	2.7	2.4	1.4	1.4	1.3	1.6	3.4	18.0
1.0 - <2.0	13.7	7.7	5.8	5.2	4.6	4.3	6.8	10.2	58.2
2.0 - <3.0	4.5	1.9	1.5	1.2	1.7	1.8	1.5	3.2	17.2
3.0 - <4.0	1.2	0.4	0.4	0.3	0.3	0.7	0.4	1.1	4.8
4.0 - <5.0	0.4	0.2	0.1	0.0	0.2	0.2	0.2	0.3	1.5
5.0 - <6.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.2
6.0 - <7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
7.0 - <8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8.0 - <9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9.0 - <10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.0 - <11.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.0 - <12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	23.6	12.8	10.3	8.1	8.2	8.4	10.4	18.2	100.0

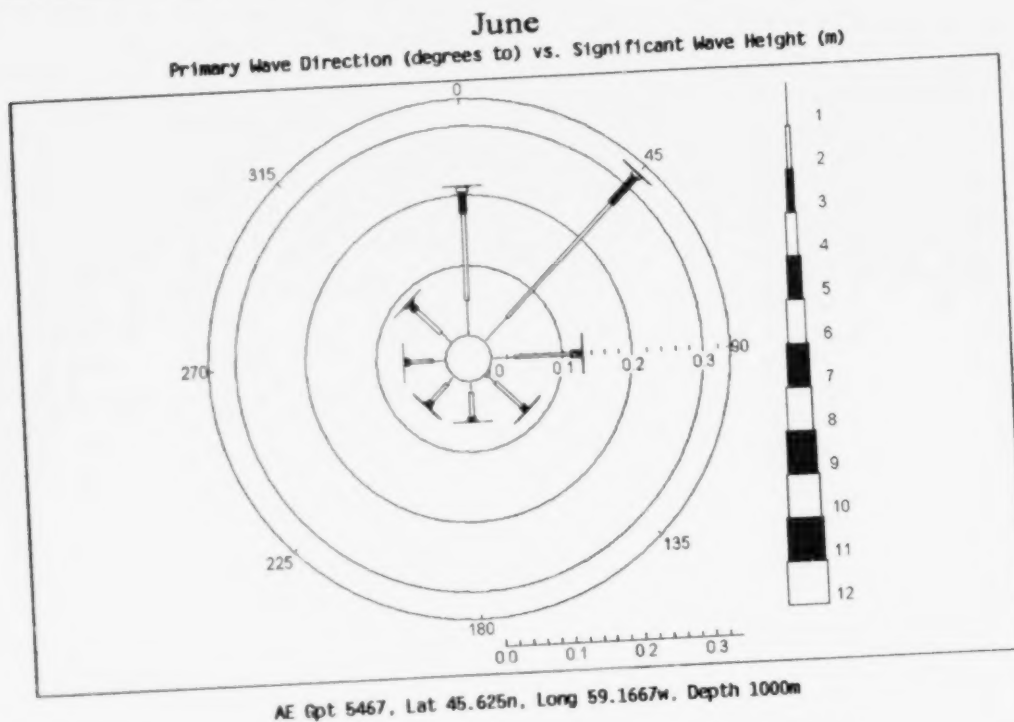


Figure A-18: June Wave Direction vs. Wave Height

Table A-18

June Percentage Frequency Occurrence of Wave Height by Direction
Source: AES40 Grid Point 5467 (45.6250N, 59.1667W) 1954 - 2003

		Wave Direction (travelling to)							Total	
		NE	E	SE	S	SW	W	NW		N
Significant Wave Height (metres)	0.0 - <1.0	4.6	3.1	1.6	1.4	1.4	1.9	2.1	5.1	21.1
	1.0 - <2.0	21.9	8.0	5.1	3.6	3.5	3.6	4.9	12.3	62.7
	2.0 - <3.0	5.1	1.5	0.8	0.5	0.6	0.6	1.2	3.0	13.4
	3.0 - <4.0	0.6	0.2	0.1	0.1	0.2	0.1	0.3	0.8	2.5
	4.0 - <5.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.3
	5.0 - <6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	6.0 - <7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	7.0 - <8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	8.0 - <9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	9.0 - <10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	10.0 - <11.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	11.0 - <12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total		32.3	12.8	7.6	5.6	5.8	6.1	8.5	21.3	100.0

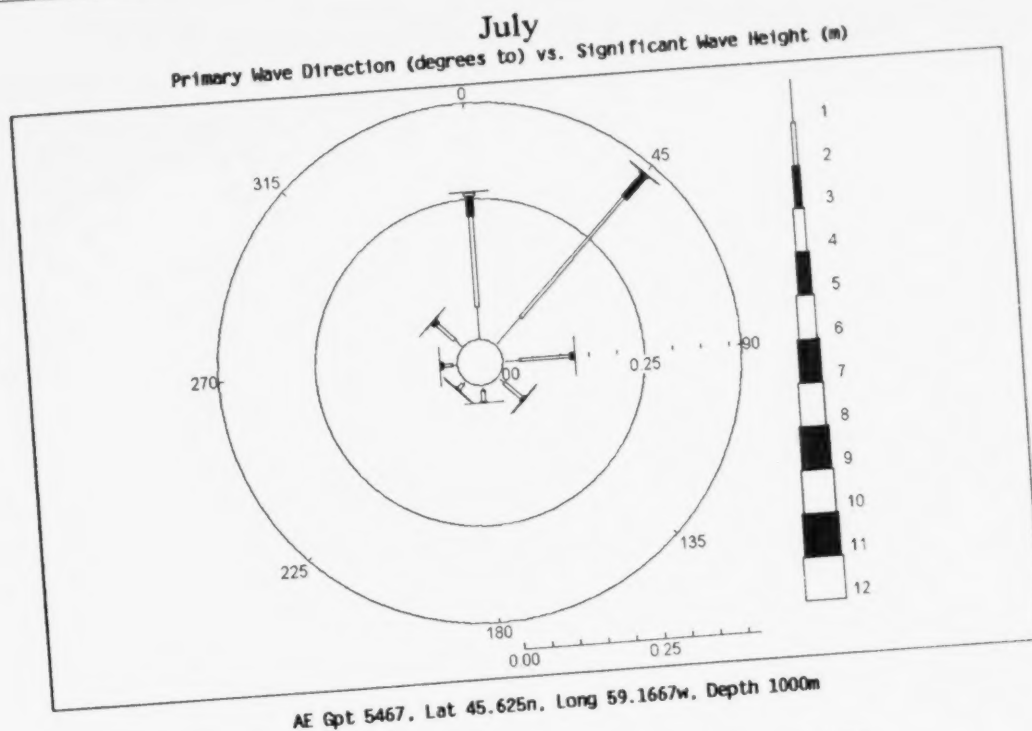


Figure A-19: July Wave Direction vs. Wave Height

Table A-19

July Percentage Frequency Occurrence of Wave Height by Direction
 Source: AES40 Grid Point 5467 (45.6250N, 59.1667W) 1954 - 2003

Significant Wave Height (metres)	Wave Direction (travelling to)								Total
	NE	E	SE	S	SW	W	NW	N	
0.0 - <1.0	6.5	2.6	1.3	0.7	0.6	0.7	1.9	5.8	20.2
1.0 - <2.0	28.0	9.1	4.0	1.9	1.3	1.7	4.3	16.1	66.4
2.0 - <3.0	5.3	0.9	0.4	0.3	0.2	0.6	0.7	3.6	12.0
3.0 - <4.0	0.4	0.1	0.1	0.0	0.0	0.0	0.1	0.6	1.3
4.0 - <5.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2
5.0 - <6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
6.0 - <7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0 - <8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8.0 - <9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9.0 - <10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.0 - <11.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.0 - <12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	40.3	12.5	5.8	2.9	2.1	3.1	7.1	26.2	100.0

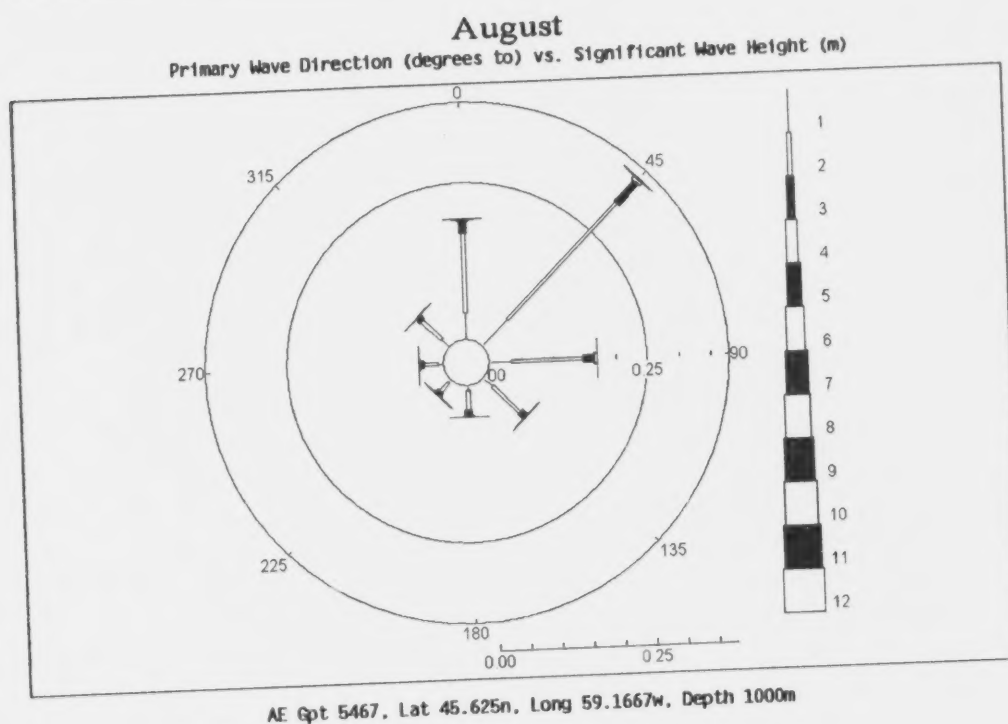


Figure A-20: August Wave Direction vs. Wave Height

Table A-20

August Percentage Frequency Occurrence of Wave Height by Direction
Source: AES40 Grid Point 5467 (45.6250N, 59.1667W) 1954 - 2003

		Wave Direction (travelling to)								Total
		NE	E	SE	S	SW	W	NW	N	
Significant Wave Height (metres)	0.0 - <1.0	5.7	3.3	1.7	0.6	0.5	0.9	1.8	4.3	18.6
	1.0 - <2.0	25.3	11.3	6.1	3.2	2.0	2.2	4.3	12.6	67.0
	2.0 - <3.0	4.5	1.9	1.1	0.9	0.4	0.7	0.8	2.0	12.3
	3.0 - <4.0	0.5	0.4	0.1	0.1	0.2	0.2	0.1	0.2	1.7
	4.0 - <5.0	0.2	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.3
	5.0 - <6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	6.0 - <7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	7.0 - <8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	8.0 - <9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	9.0 - <10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	10.0 - <11.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	11.0 - <12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total		36.2	16.9	8.9	4.8	3.1	4.0	7.0	19.2	100.0

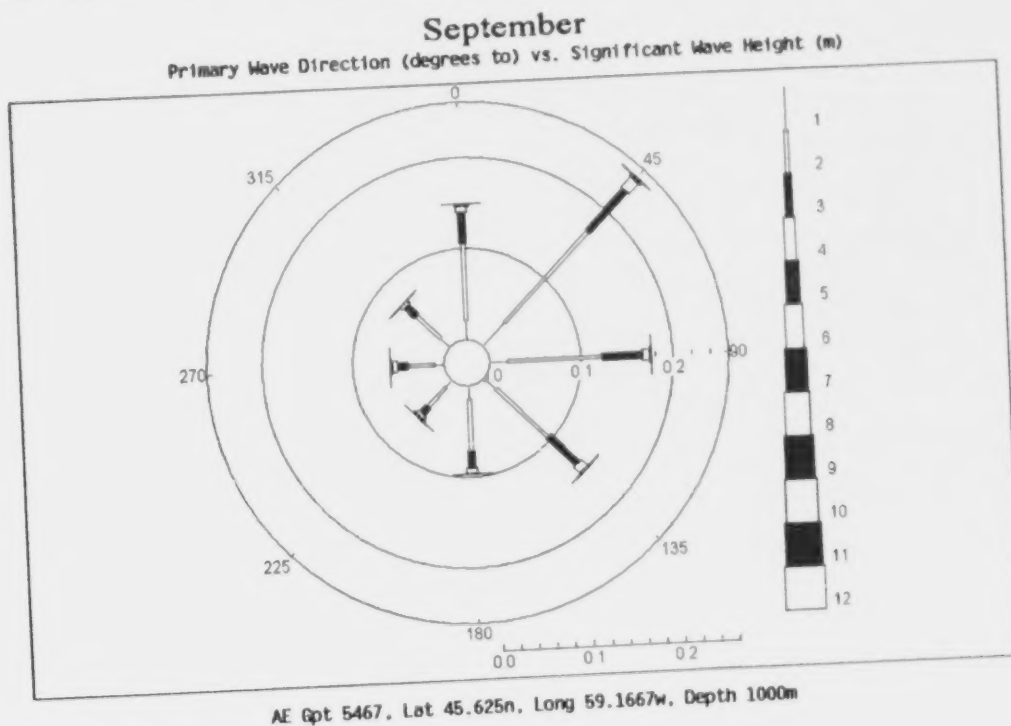


Figure A-21: September Wave Direction vs. Wave Height

Table A-21

September Percentage Frequency Occurrence of Wave Height by Direction
Source: AES40 Grid Point 5467 (45.6250N, 59.1667W) 1954 - 2003

	Wave Direction (travelling to)								Total
	NE	E	SE	S	SW	W	NW	N	
0.0 - <1.0	3.4	1.7	1.6	1.3	1.0	1.0	1.5	2.1	13.4
1.0 - <2.0	13.5	10.4	7.8	5.7	2.9	3.1	3.7	8.5	55.5
2.0 - <3.0	6.1	4.4	4.4	1.9	1.0	1.1	1.5	3.4	23.8
3.0 - <4.0	1.5	0.8	0.9	0.5	0.3	0.5	0.4	0.7	5.7
4.0 - <5.0	0.3	0.1	0.1	0.1	0.2	0.1	0.0	0.2	1.1
5.0 - <6.0	0.1	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.4
6.0 - <7.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1
7.0 - <8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8.0 - <9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9.0 - <10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.0 - <11.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.0 - <12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	24.9	17.6	14.8	9.5	5.4	5.9	7.0	14.8	100.0

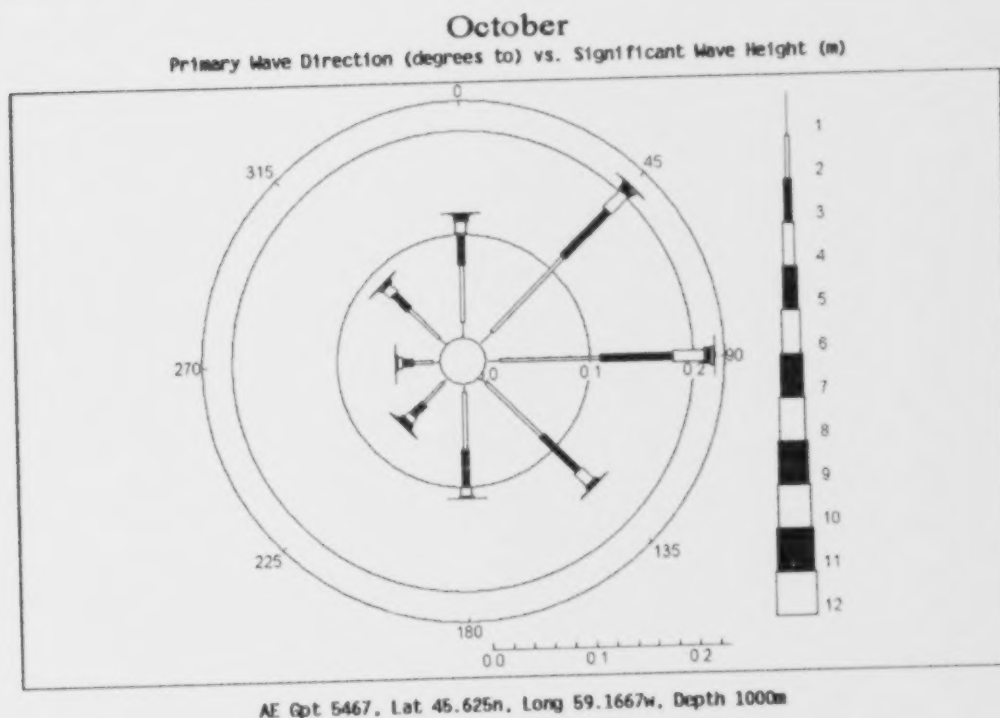


Figure A-22: October Wave Direction vs. Wave Height

Table A-22

October Percentage Frequency Occurrence of Wave Height by Direction
Source: AES40 Grid Point 5467 (45.6250N, 59.1667W) 1954 - 2003

	Wave Direction (travelling to)								Total
	NE	E	SE	S	SW	W	NW	N	
0.0 - <1.0	1.7	1.3	0.8	0.7	0.5	0.7	1.0	1.5	8.1
1.0 - <2.0	9.9	9.6	7.4	5.5	2.8	1.9	4.1	5.6	46.8
2.0 - <3.0	6.2	7.0	4.9	3.7	1.6	1.0	2.0	3.0	29.3
3.0 - <4.0	2.3	3.0	1.6	0.9	0.7	0.5	1.0	1.2	11.2
4.0 - <5.0	0.7	0.7	0.3	0.1	0.3	0.1	0.2	0.5	3.0
5.0 - <6.0	0.2	0.3	0.1	0.1	0.2	0.0	0.2	0.1	1.1
6.0 - <7.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.3
7.0 - <8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
8.0 - <9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
9.0 - <10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.0 - <11.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.0 - <12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	21.0	21.9	15.1	10.9	6.2	4.4	8.5	12.0	100.0

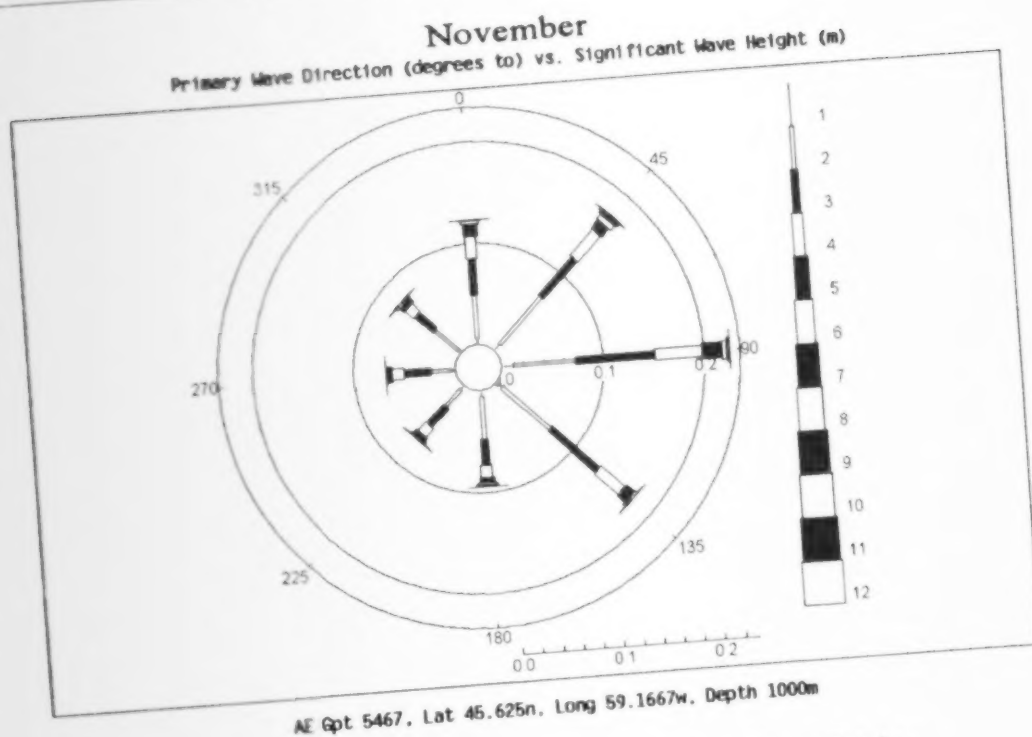


Figure A-23: November Wave Direction vs. Wave Height

Table A-23

November Percentage Frequency Occurrence of Wave Height by Direction
 Source: AES40 Grid Point 5467 (45.6250N, 59.1667W) 1954 - 2003

Significant Wave Height (metres)	Wave Direction (travelling to)								Total
	NE	E	SE	S	SW	W	NW	N	
0.0 - <1.0	0.7	1.0	0.6	0.5	0.5	0.3	0.3	0.6	4.4
1.0 - <2.0	6.2	6.2	6.2	4.1	2.2	2.1	3.1	4.3	34.3
2.0 - <3.0	4.9	7.9	6.3	2.6	2.4	2.7	2.3	3.6	32.6
3.0 - <4.0	3.4	4.7	3.1	1.2	1.2	1.1	1.1	2.2	18.0
4.0 - <5.0	1.1	1.9	1.0	0.5	0.4	0.4	0.6	1.2	7.0
5.0 - <6.0	0.6	0.5	0.2	0.2	0.1	0.1	0.2	0.3	2.2
6.0 - <7.0	0.3	0.2	0.1	0.1	0.1	0.1	0.0	0.1	0.9
7.0 - <8.0	0.2	0.1	0.0	0.1	0.1	0.0	0.0	0.1	0.5
8.0 - <9.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
9.0 - <10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.0 - <11.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.0 - <12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	17.3	22.3	17.5	9.4	6.9	6.8	7.6	12.2	100.0

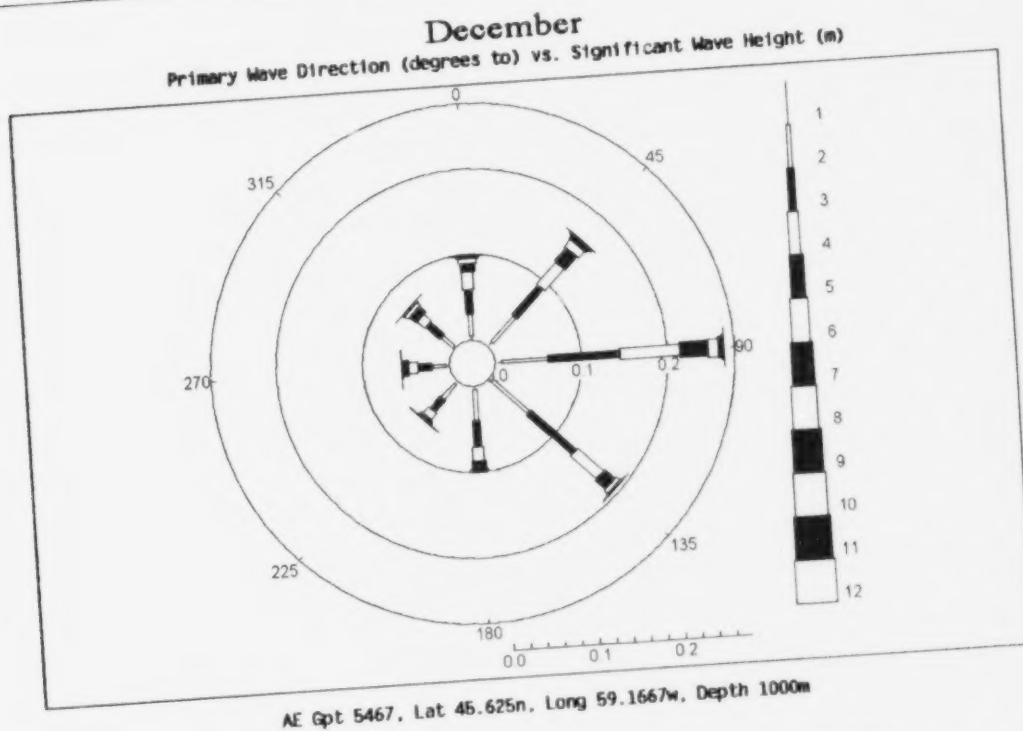


Figure A-24: December Wave Direction vs. Wave Height

Table A-24

December Percentage Frequency Occurrence of Wave Height by Direction
Source: AES40 Grid Point 5467 (45.6250N, 59.1667W) 1954 - 2003

Significant Wave Height (metres)	Wave Direction (travelling to)								Total
	NE	E	SE	S	SW	W	NW	N	
0.0 - <1.0	0.6	0.5	0.2	0.3	0.4	0.4	0.2	0.4	2.9
1.0 - <2.0	4.0	5.5	5.6	3.6	2.2	1.7	1.9	2.7	27.1
2.0 - <3.0	4.5	8.4	7.1	3.0	1.8	1.6	2.2	2.8	31.2
3.0 - <4.0	3.4	7.0	4.0	1.7	1.0	1.1	1.2	2.2	21.6
4.0 - <5.0	2.1	3.2	1.5	0.9	0.3	0.6	1.0	0.9	10.4
5.0 - <6.0	1.0	1.3	0.5	0.2	0.2	0.1	0.6	0.6	4.4
6.0 - <7.0	0.4	0.5	0.2	0.1	0.0	0.1	0.2	0.2	1.6
7.0 - <8.0	0.1	0.2	0.1	0.0	0.1	0.0	0.0	0.1	0.5
8.0 - <9.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
9.0 - <10.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
10.0 - <11.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.0 - <12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	16.2	26.4	19.2	9.8	5.9	5.6	7.1	9.8	100.0

[illegible]

Species	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
LAB_RF	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BNTHEMA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
HER_CAPE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
LHORN_S	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SHORN_S	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SCULPIN	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GATORF	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
STICKLEB	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MONKFISH	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SEASNAIL	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
LUMPFISH	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000
AMER_SL	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
EEL	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.000	0.000	0.000	0.000	0.003
NORTH_SL	0.000	0.000	0.000	0.000	0.000	1.078	0.473	0.009	0.001	0.000	0.000	0.000
SANDLANC	0.000	0.002	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RGUNNEL	0.000	0.000	0.000	0.000	0.000	0.006	0.002	0.000	0.000	0.000	0.000	0.000
BLENNY	0.000	0.000	0.001	0.000	0.000	0.003	0.001	0.000	0.000	0.000	0.000	0.000
SHANNY_A	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000
SHANNY_R	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
WRYMOUTH	0.000	0.000	0.000	0.000	0.000	0.006	0.006	0.000	0.000	0.000	0.000	0.000
SHANNY	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000
BUTTERF	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SAURY	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BCUDINA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
PUFFER	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ANGLEMOU	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SNAKEF	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GOBIES	0.000	0.000	0.000	0.000	0.000	1.119	0.514	0.048	0.057	0.093	0.026	0.044
TOTAL	0.000	0.008	0.017	0.000	0.000	1.119	0.514	0.048	0.057	0.093	0.026	0.044